CSEDU 2013

5th International Conference on Computer Supported Education

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Aachen, Germany

6 - 8 May, 2013

CSEDU 2013

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FOREWORD

This book contains the proceedings of the 5th International Conference on Computer Supported Education (CSEDU 2013) which was organized and sponsored by the Institute for Systems and Technologies of Information, Control and Communication (INSTICC) and co-organized by RWTH Aachen University. This conference was held in Cooperation with the Association for Computing Machinery - Special Interest Group for Information Technology Education and technically co-sponsored by ROLE (Responsive Open Learning Environments), IGIP (International Society for Engineering Education), and IFIP (International Federation for Information Processing).

CSEDU has become an annual meeting place for presenting and discussing learning paradigms, best practices and case studies that concern innovative computer-supported learning strategies, institutional policies on technology-enhanced learning including learning from distance, supported by technology. The Web is currently a preferred medium for distance learning and the learning practice in this context is usually referred to as e-learning or technology-enhanced learning. CSEDU 2013 provided an overview of the state of the art in technology-enhanced learning and outlined upcoming trends and promoting discussions about the education potential of new learning technologies in the academic and corporate world.

This conference brought together researchers and practitioners interested in methodologies and applications related to the education field. It had five main topic areas, covering different aspects of Computer Supported Education, including “Information Technologies Supporting Learning”, “Learning/Teaching Methodologies and Assessment”, “Social Context and Learning Environments”, “Domain Applications and Case Studies” and “Ubiquitous Learning”. We believe these proceedings demonstrate new and innovative solutions, and highlight technical problems in each field that are challenging and worthwhile.

CSEDU 2013 received 208 paper submissions from 56 countries in all continents. A double-blind review process was enforced, with the help of the 235 experts who were members of the conference program committee, all of them internationally recognized in one of the main conference topic areas. Only 27 papers were selected to be published and presented as full papers, i.e. completed work (10 pages in proceedings / 30’ oral presentations). Another 49 papers, describing work-in-progress, were selected as short papers for 20’ oral presentation. Furthermore 34 papers were presented as posters. The full-paper acceptance ratio was thus 13%, and the total oral paper acceptance ratio was less than 36,54%. These ratios denote a high level of quality, which we intend to maintain and reinforce in the next edition of this conference.

The high quality of the CSEDU 2013 programme was enhanced by four keynote lectures, delivered by experts in their fields, including (alphabetically): Bruce McLaren (Carnegie Mellon University, United States and Saarland University, Germany), Michael E. Auer (Carinthia Tech Institute, Austria), Rob Reilly (MIT, United States) and Susan Zvacek (Fort Hays State University, United States).

For the fifth edition of the conference we extended and ensured appropriate indexing of the proceedings of CSEDU including Thomson Reuters Conference Proceedings Citation Index, INSPEC, DBLP and EI. Besides the proceedings edited by SCITEPRESS, a short list of papers presented at the conference will be selected for publication of extended and revised versions in the International Journal of Engineering Pedagogy. Furthermore, all presented papers will soon be available at the SCITEPRESS digital library.

The best contributions to the conference and the best student submissions were distinguished with awards based on the best combined marks of paper reviewing, as assessed by the Program Committee, and the quality of the presentation, as assessed by session chairs at the conference venue.

The conference was complemented with a special session, focusing on cloud education environments; named Working Session on Cloud Education Environments (WCLOUD 2013).

Building an interesting and successful program for the conference required the dedicated effort of many people. Firstly, we must thank the authors, whose research and development efforts are recorded here. Secondly, we thank the members of the program committee and additional reviewers for their diligence and expert reviewing. We also wish to include here a word of appreciation for the excellent organization provided by the conference secretariat, from INSTICC, which has smoothly and efficiently prepared the most appropriate environment for a productive meeting and scientific networking. Last but not least, we thank the invited speakers for their invaluable contribution and for taking the time to synthesize and deliver their talks.

Markus Helfert
Dublin City University, Ireland

Owen Foley
Galway Mayo IT, Ireland

Maria Teresa Restivo
FEUP, Portugal

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University of Ulster, U.K.

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The Educational Software Gold Rush

How the Learning Sciences and Advanced Technology Can Lead the Way

Bruce McLaren
Carnegie Mellon University, U.S.A.
Saarland University, Germany

Abstract: In today's world, young people are immersed in technology and thus expect it to play a key role in their education. In tune with this trend, there has been a proliferation of internet-based learning software, educational games, and instructional technology, such as Cognitive Tutors (www.carnegielearning.com), Study Island (www.studyisland.com), BrainPop (www.brainpop.com), Civilization (http://en.wikipedia.org/wiki/Civilization_IV) and the Khan Academy (www.khanacademy.org). Many schools provide their students with tablet computers so they can access this ever-widening variety of online learning software. Yet, in the midst of this "gold rush" toward educational software, are we on a firm foundation? Important questions emerge: Can the Learning Sciences and advanced technology – most specifically artificial intelligence – lead us on a path toward the "gold"? What still needs to be done to "mine the gold" of educational technology? In this talk I will discuss how science and technology have and are coming together to support the educational software gold rush. Together, the Learning Sciences and advanced technology, I conjecture, can lead the way toward the design and development of the best possible learning environments for 21st century students.

BRIEF BIOGRAPHY

Dr. Bruce M. McLaren is a senior systems scientist at Carnegie Mellon University (USA) and an adjunct principal researcher with the Center for e-Learning Technology (CeLTech), Saarland University (Germany). McLaren is passionate about how technology can support education and has dedicated his work and research to projects that explore how students can learn with Internet-based educational software. He is particularly interested in intelligent tutoring systems, e-learning principles and collaborative learning and technology for supporting and analyzing collaborative argumentation. He has more than 100 publications spanning peer-reviewed journals, conferences, workshops, symposiums and book chapters. McLaren has a Ph.D. and M.S. in intelligent systems and an M.S. in computer science from the University of Pittsburgh (USA), as well as a B.S. (cum laude) in computer science from Millersville University. His webpage is http://www.cs.cmu.edu/~bmclaren/index.html.

New Challenges in Engineering Education

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EXTENDED ABSTRACT

Starting from actual tendencies in engineering and education the talk will highlight new requirements in engineering education.

In the literature we can find different definitions of the term Engineering.

But in sum a short definition of engineering might be: Exploiting basic principles of science to develop useful tools and objects for society.

This means that engineering is the link between science and society, which can include almost anything that people come into contact or experience in real life. The concept of engineering has existed long before recorded history, and has evolved from fundamental inventions such as the lever, wheel and pulley to the complex examples of engineering today. But today, there are some actual tendencies:

- We observe the enormous and driven growth of the area of engineering. Besides the traditional fields of civil engineering, construction engineering, electrical engineering, etc. many new engineering disciplines occur.
- And new tasks requiring new competencies within traditional engineering disciplines have grown in number and complexity.
- Never has the speed of development in the area of engineering been as accelerated as it is today. We can observe a terrific acceleration of the life cycles of technical (or engineering) products Competition in the field of technology is now measured in month and weeks.
- Furthermore the focus of the engineering disciplines is shifting from pure technical subjects to subjects directed to Information Technologies and the daily life of mankind.
- Engineering issues, either in industrial products or in engineering projects, are quickly becoming increasingly complicated and most of these issues cross disciplinary lines.
- The working environment of engineers is becoming more and more internationalized due to the globalization of the world economy. Products are fabricated by worldwide cooperation and manufacturing resources are linked by international supply chains. Nowadays, engineers have to know how to work in multi-cultural environments with people from different countries.

On the other hand a mayor shift happens in educational processes in general. Some of these tendencies for the future of learning are:

- The future of learning will require the conceptualization and implementation of a new learning model. We need to be focusing more 21st century competencies and expertise such as critical thinking, complex problem solving, interactive collaboration, etc.
- The future of learning will be a balanced approach between E-Learning and Face-to-Face Learning; between Formal and Informal Learning. A modern approach of teaching and learning is a blended one. This is my deep belief. We have to better exploit synergies from traditional and non-traditional education.
- The future of learning will revolve more around context than content. Our age is the Information Age. We live in the Knowledge Society where data, information, knowledge are easy to access 24/7. We need a radical change from teaching facts and knowledge to convey skills and creativity (to find necessary data, facts, and knowledge) in a global context. Therefore, learning is presently undergoing great transitions.

- The Future of Learning will be a global one, characterized by open content, open knowledge, open technology for all. Global education is the next distance-learning leap. Especially from this the necessity of a new business model in education arises.
- The future of learning is characterized by serious changes in the social position of learning. According to some estimates, more than 80% of all learning occurs on the job rather than in tertiary and post-tertiary education. Learning in the future has to be an integrated part of the job! People of all ages have to renew their knowledge in decreasing cycles. This is what we understand as "Life Long Learning".

All these tendencies in engineering and education require concerted new efforts in engineering education.

An important term in this direction is Online Engineering. On the one hand Online Engineering will be the typical future way of working of engineers. On the other hand Online Engineering is an important tool for a contemporary engineering education.

BRIEF BIOGRAPHY

Prof. Dr.-Ing. Dr.sc. Dr. h.c. Michael E. Auer is with Systems Engineering Dept. of the CTI Villach, Austria and has also a teaching position at the University of Klagenfurt. Furthermore he works as a visiting professor at the Universities of Amman (Jordan), Brasov (Romania) and Patras (Greece).

He is a senior member of IEEE and member of IGIP, IAOE, etc., author or co-author of more than 180 publications and leading member of numerous national and international organizations in the field of online technologies.

Michael Auer is Founding-President and CEO of the "International Association of Online Engineering" (IAOE) since 2006, a non-governmental organization that promotes the vision of new engineering working environments worldwide.

In September 2010 he was elected as President of the "International Society of Engineering Education" (IGIP).

Michael Auer has experience in leading of several national and international projects in the fields of remote engineering and technology supported learning.

What Is: Pedagogy, Education, Intelligence, Knowledge, Learning, Teaching, Information, Etc. and Why Do We Care about What They Are, and How Do They Interact?

Rob Reilly
MIT, U.S.A.

Abstract: As educators we are familiar with terms such as: education, learning, knowledge, wisdom, information, teaching, intelligence. These concepts are all important to us; but it seems that their meaning, how they are applied, and how we interpret them in light of evolving pedagogy is quickly evolving. Understanding these terms and understanding how they fit-into a model for delivering 'education' for a model based knowledge domain (e.g., science, engineering) is critically important. This presentation will shed some light on the definations of terms that we use in 'education' and will provide an understanding how these various concepts (e.g., information, intelligence, learning, wisdom) fit into a model for effectively delivering content from a model-based knowledge domain.

BRIEF BIOGRAPHY

Dr. Rob Reilly received a Doctoral degree and Bachelor's degree from the University of Massachusetts at Amherst (USA), as well as a Master's degree from Springfield College (Massachusetts USA).

He has been a computer science teacher at various institutions for over 30 years. Some highlights of his career include: serving in the Office of Information Technologies at the University of Massachusetts at Amherst, where his research dealt with the formulation of university wide policy for the integration and application of educational technology; serving as a researcher at the Institute of Intelligent Systems at the University of Memphis (Tennessee USA); and service as a researcher in the Media Lab at the Massachusetts Institute of Technology (MIT).

In the IEEE Education Society, Dr. Reilly is the 2011-2012 President; he is, oddly-enough, also its Vice President for Chapters Activity.

He has received IGIP's Nikola Tesla Medal in 2012 for excellence in teaching pedagogy, the IEEE-MGA Leadership Award, the IEEE Larry K. Wilson Transnational Award, the IEEE Education Society's Edwin Jones Jr. Meritorious Service Award, the IEEE Computer Society's Contributions in a Pre-University Environment Award, and the Massachusetts Department of Educations Technology Pathfinder Award.

Tech-Savvy Students? Maybe Not …

Susan M. Zvacek
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Abstract: It’s easy to assume that our students are technologically adept and ready to take advantage of the many resources available online. Unfortunately, recent research suggests that growing up in a tech-enriched environment does not result in the ability to use digital tools effectively. Instead, many young people lack important conceptual and intellectual capabilities that would allow them to understand, apply, and evaluate online content. This presentation will address the skills that contribute to technological literacy, popular myths related to “digital natives,” and how we can help our students become critical consumers and users of digital tools and resources.

1 WHAT IS TECH LITERACY?

Back in ancient days (i.e., 1996), the U.S. Department of Education defined technological literacy as, “Computer skills and the ability to use computers and other technology to improve learning, productivity, and performance" (U.S. Dept. of Ed.). Over time, however, the focus on hardware and software has evolved and more recent definitions include elements related to using technology “responsibly, creatively, and effectively,” as well as the ability to “create, manage, and evaluate information.” In fact, the phrase *technological literacy* has been subsumed by the more inclusive term *digital information literacy* in the research literature, with its connotations of relevant communication skills and information seeking. And, while it might be natural to assume that our students, many of whom have grown up in a technologically-rich environment, would display a natural affinity for manipulating digital information this is not proving to be the case (Hargittai, 2010; Gros, et al, 2012).

Research conducted within the past ten years strongly suggests that our students are tech-savvy in rather task-specific ways. They can use mobile phones, surf the internet, and play video games, and many can create mash-ups from a wide variety of digital resources. What they are less adept at, however, are the intellectual skills that would enable them to critically evaluate those resources, recognize bias, engage in complex reasoning, build a persuasive argument, or identify ethical issues dealing with privacy or intellectual property, for example. And, for all the hoopla and publicity garnered by authors writing about the “net generation,” there is no actual research supporting the idea that this age group learns in fundamentally different ways or that their brains are somehow physically differently from earlier generations. What we do know is that the world is a new place and new skills are needed, but those skills will be obtained through learning experiences, not some mystical process dependent on proximity to computers.

2 WHAT ARE DIGITAL INFORMATION LITERACY SKILLS AND WHY ARE THEY IMPORTANT?

The abilities our students need can be categorized as: 1) Hands-on Skill Sets, 2) Conceptual Knowledge, and 3) Intellectual Capabilities. Hands-on skills are focused on productivity and include being able to use communication and collaboration tools (e-mail, chat, blogs, discussion boards, etc.), word processing, spreadsheets, databases, and search engines. Learners should be able to use advanced features of these applications and also know how to use supporting documentation or help files to further their understanding and skills.

Conceptual knowledge requires that users understand key ideas related to digital technology, such as network structures, how search engines work, what databases are and how they’re organized, and what technology can and cannot do. Here the emphasis is on concepts about technology and learners should be able to articulate their thinking on these topics.

Finally, intellectual capabilities related to digital information literacy require learners to engage in higher order thinking about technology. Within the realm of technological environments and applications, our students should be able to engage in problem solving, collaborate with others, evaluate information and information sources, manage complex sets of data, and explore multiple perspectives on current issues.

Digital information literacy skills are essential if learners hope to be competitive in today's workforce, but these capabilities go beyond job training. A well-informed citizenry, capable of utilizing a variety of information resources and evaluating their credibility benefits society as a whole and can propel scientific and social progress.

3 SUMMARY

It's easy to assume that our students are technologically adept and ready to take advantage of the many resources available online. Unfortunately, recent research suggests that growing up in a tech-enriched environment does not result in the ability to use digital tools effectively. Instead, many young people lack important conceptual and intellectual capabilities that would allow them to understand, apply, and evaluate online content. It is our job to equip student with opportunities to develop relevant hands-on skills, conceptual knowledge, and critical thinking abilities enabling them to use various technologies wisely.

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BRIEF BIOGRAPHY

Susan M. Zvacek has been involved with higher education for more than twenty years and has worked in community college, corporate, university, and adult education environments. Currently, she is the Senior Director for Teaching Excellence and Learning Technologies at Fort Hays State University, in Hays, Kansas. Dr. Zvacek holds a B.A. in Speech from Iowa State University, a Master's in Education from the University of Utah, and a Ph.D. in Curriculum and Instructional Technology, also from Iowa State University.

Her scholarly work has been primarily in the field of educational technology, with publications and presentations at national and international conferences on topics such as higher order thinking skills, distance education, and the assessment of learning using online tools. She is co-author of a popular textbook, *Teaching and Learning at a Distance* (now in its fifth edition) and *Blackboard for Dummies*.

INFORMATION TECHNOLOGIES SUPPORTING LEARNING

FULL PAPERS

A Project-based Creative Product Design Course using Learning Management System

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Keywords: Creative Product Design, Project-based Approach, Learning Management System, Pedagogical Issues.

Abstract: This study presents an effective mode for creative product design learning through practical tasks generation by learner groups in a face-to-face course. This mode integrates project-based learning, and learning management techniques and tools. We include a quasi-experimental study in which the results of four academic years are analyzed. In this study we analyze phases such as exam grades, exam dropout rates, exam passing rates, and class attendance. Meanwhile, we also investigate the use of LMS, distinguishing between informational use and communicational use. The predictive model further involves: utility, user interface, subjective criterion, personal innovativeness in the domain of information technology and internal ICT support at school aspect. Learners that followed this active learning approach gained better results than those that followed a traditional strategy. In addition, the experience of the introduction of such a method in a student subgroup positively influenced the whole group. Finally, information use was found to be a precursor for communicational use, perceived user interface of the LMS is the strongest predictor in LMS acceptation. Internal ICT support has a direct effect on the information use of the LMS and on subjective criterion.

1 INTRODUCTION

Instructional methods traditionally used for computer-aided creative product design involve expositional lectures, and closed and hands-on laboratories. We will refer to this as “traditional mode” in the rest of the study. Nevertheless, some researches proposed that this mode seems to be problematic or even ineffective for the abstract and complex domain of creative product design (Howard et al., 2008; de Vere et al., 2010). One promising method in this field is based on the development of projects (Howard et al., 2008). Project-based learning (PBL) is a constructivist pedagogy that intends to bring about deep learning by allowing learners to use an inquiry based approach to engage with issues and questions that are rich, real and relevant to the topic being studied. It is designed to be used for complex issues that require learners to investigate in order to understand (Barron, 1998). Within this type of learning, learners are expected to use technology in meaningful ways to help them investigate or present their knowledge. Technology is infused throughout the project to reflect the emphasis on technological and academic content. PBL framework differs from inquiry-based activity in its emphasis on cooperation between team members. Cooperation refers to the practice of working in line with commonly agreed goals and possible methods, instead of working separately in competition. The several different approaches in project-based learning (ChanLin, 2008), which differ in project duration, number of team members, and in the way the learners cooperate. In summary, there are many benefits of PBL covered in the literature, For example, the possibility of increasing motivation, of connecting learning with reality, promoting problem-solving and teamwork, among others.

Project management is the application of knowledge, techniques, skills, and tools to meet project requirements (Project Management Institute, 2008). To integrate both perspectives of a project as an effective creative product design learning method, using PBL with aim of undertaking a software project that covers all the activities. The result of this integration should benefit from both PBL techniques and professional practices. Furthermore, we also organize, mange and controls the development of project tasks and their deliverables through the adoption of learning management systems (LMS) in a face-to-face course, in order to reduce the management time. The last objective is to investigate the results of two academic years using PBL approach and the technology acceptation of LMS.

2 COMPUTER'S ROLES: COURSE SOFTWARE AND LMS

Several of the project tasks need the use of three software programs for their development, computer-aided design system, a text editor, and a data store system. We present, in laboratories, their main functions, accessible from the graphical tool Management Studio. This makes it possible to deal with physical design in a subsequent task. Through the realization of these tasks, learners face several real-world features such as product specification, design constraints, data editing and storing, backups, etc. Furthermore, we adopted the institutional and commercial LMS tool Blackboard/WebCT Learning System® (Blackboard, 2012), other similar solutions, of course, could be also useful for our goals. This tool is applied as a support of a face-to-face course. This tool has been used to meet several primary requirements:

(1) Task management: this tool collect the deliverables, automatically registers the submission date and time, and allows for delivering several versions for the same task. Once delivered, it is possible to send the feedback to the group and also to assess the task. We use this tool as an organized repository. Both learners and instructors have access to the repository that can be checked in case of conflict.
(2) Group management: This tool allows us to update the group composition and automatically create a kind email distribution list useful for communication with the groups. It also to assign the groups to panels. Learners identify themselves when starting a session and the LMS uses this identify for all its tools. We also use the evaluation module to collect the individual report of the time spent on each task.
(3) Communication: there are several communication modules provided: announcement, calendar, email and panel modules. With the announcements the learners read instructor news at the beginning of a session. The calendar displays all the interesting events related to the project, as task deadlines. These events are easily created as part of the task definition. E-mail allows personal communication, for instance between a learner and the instructors. The panels permit the participation of authorized learners and instructors. To meet several purposes, three types of panels are used in this tool: (i) a public inter-groups panel for all group members. It should be used for general questions and to explain possible mistakes or problems. (ii) a private intra-groups panel is built for each group. It should be used for communication purposes among group members. (iii) a private intra-project panel is defined for each project domain. The panel is anonymous and constitutes the only communication channel between both groups. We look for a similar mechanism to moderated distribution lists. In this way, the instructor could superintend the contents of each message before publishing it in order to avoid inappropriate contribution.
(4) Description of learning method: Presented here are the general rules, the acquired agreements, the assessment method, the enumeration of the different tasks, including the estimated tasks deadlines and workload and the course schedule (involving lectures and labs).

At the beginning of the first project task, the participants have access to the first task description through the task module. The rest of the tasks are gradually incorporated through this module. Whenever a new task is available, the module highlights this to the students with a graphical representation on the main page. Each task includes a detailed description of what should be delivered before its deadline. Tasks can also be sent for a while after the time limit. Instructors and students can consult all the past tasks and easily access their deliverables during the whole project. Furthermore, group management workload was reduced as a result of LMS. We have shown its usefulness for interchanging instructions, asking and replying to questions, providing feedback, receiving and storing work results, and so on. The module requires a brief reconfiguration for each course: assigning task deadlines, defining the groups, adding new groups to the panels and tasks, etc. However, most of the work is reused from previous courses: method description, generation of panel, task presentations and definitions, and so forth.

3 RESEARCH HYPOTHESES

3.1 Project-based Method

The following hypotheses make conjectures on student results. These results include aspects such as dropout rates, exam passing, and class attendance. Better results mean more valuable learning outcomes for the students. The several hypotheses that we wish to examine are:

H1a: Students that follow the project-based method will obtain better results than their counterparts with a traditional method.

H1b: The project-based method will influence the whole student group: the results of the entire group when some students follow the new method will be better than the results of the group when everybody follows a traditional method.

H1c: The project-based method will influence the students that only follow a traditional method: these students will improve their results compared with groups of students where all their members follow a traditional method.

3.2 The Informational LMSuse

Malikowski, Thompson and Theis (2007) distinguish several layers of adoption with respect to CMS features: Layer 1, consisting of the most commonly used CMS features such as transmitting course content; Layer 2, comprising features with moderate adoption such as evaluating learners, courses and instructors; and Layer 3, including the least adopted features like creating class discussions and computer-based instruction. Features of layer 1 can be seen as features focusing on what Hamuy and Galaz (2010) refer to as the informational phase, while layer 2 and 3 correspond with the communicational phase (Hamuy and Galaz, 2010). Malikowski et al. (2007) concluded that CMS features for evaluating students or creating discussions are adopted much less often than transmitting content, so the flowchart suggests categories containing these features are adopted after instructors have transmitted content in a CMS. All these observations and arguments have in common that a basic usage phase of specific technologies, is required to foster the adoption of more advanced type of technology use. Hence, within the context of the study about LMS usage, we expect information use of the LMS to be a precursor of communicational use.

H2: Informational use will be a precursor of communicational use.

3.3 Perception of LMS

The perception of utility is defined as the degree to which a person believes that using a particular system will enhance job performance (Ware, 2004). In most TAM-studies, perception of utility has been the strongest predictor for behavioral intention. Therefore, King and He (2006) conclude their meta-analysis with the statement: “if one could measure only one independent variable, perception of utility would clearly be the one to choose”. But even if users think their performance will benefit from technology usage, they do not necessarily actively engage with the technology. Ware (2004) explains this as follows: “they may, at the same time, believe that the system is too hard to use and that the performance benefits of usage are outweighed by the effort of using the application” (p. 320). In this respect, the variable, perception of user interface, plays a role. It refers to an individual’s believe that using a system or technology is free of effort. Meanwhile, the variable, subjective criterion, refers to the social influence of important others (Ma et al., 2005). Though Ware (2004) did not include social influence as a direct determinant of behavioral intention, Venkatesh and Davis (2000) reconsidered this variable in the TAM2 model, especially in settings where a particular technology usage is mandatory. Van Raaij and Schepers (2008) refer in this context to LMS environments when they have to be used in order to complete the course. This reconfirms the position of subjective criterion in the present study. There are several hypotheses included in our model.

H3a: Perception of utility has positively affects informational use.

H3b: Perception of user interface has positively affects informational use.

H3c: Perceived user interface positively affects perceived utility.

H3d: Subjective criterion positively affects perception of utility.

3.4 Personal Innovativeness toward IT

Van Raaij and Schepers (2008) consider personal innovativeness as a form of openness to change. They agree with Schillewaert et al. (2005) that “being used to adapting to new systems and processes might indicate the utility and user interface more quickly to an innovative person than to a non-innovative person”. As reported by Schillewaert et al. (2005), it is not only possible to distinguish a direct relation between personal innovativeness and technology adoption, but also an indirect relation through perception of utility and user interface. They concluded that a person's predisposition toward technology plays an important role. In this respect, we expect that a learner with a higher level of technological innovativeness will more readily use an LMS, and this up to the communicational phase.

H4a: Personal innovativeness toward IT positively affects communicational use.
H4b: Personal innovativeness toward IT positively affects perception of utility.
H4c: Personal innovativeness toward IT positively affects perception of user interface.

3.5 Internal Support toward IT

Technical support is one of the most essential factors in the acceptance of educational technology (Wu, Hiltz & Bieber, 2010). Ngai et al. (2007) also stated a strong – indirect – effect of technical support on attitude, thus underscoring the importance of user support and training on the perceptions of users and ultimately their use of system. This is confirmed by the significant and strong association between user perceptions of school-based ICT support and actual classroom use of ICT in the study of Tondeur, van Keer et al. (2008). Thus, we can assume that internal ICT support will influence the perceptions of the learners and the use of the LMS.

H5a: Internal support toward ICT positively affects informational use.
H5b: Internal support toward ICT positively affects subjective criterion.

4 METHOD

4.1 Participant

This is a quasi-experimental study based on a face-to-face course on creative product design with one team of students per academic year. We will identify each academic year by its final year. For example, we will refer to the academic year 2010/2011 as 2011. The sample corresponds to four successive courses, from year 2008-2011, with 78, 85, 96, and 93 students attending the course, respectively. From year 2010 the project-based method was provided as an alternative and was optional to all the students. All the interested members were admitted. A total of 116 students followed this method (56 in 2010 and 60 in 2011) organized in 29 groups. All the groups had four members.

4.2 Research Design

For each academic year the two instructors were the same. Each lecturer was responsible for the same portions each year. The subject contents, books and written materials were also substantially the same. To investigate the previous hypotheses (H1a – H1c) we use the exam grades, which constitute the common assessment procedure for both learning methods. All the exams follow a common structure. They all are composed of the same set of exercise with very similar difficulty level among them. We also consider the number of students that did not take the exam and the student class attendance. Individual declarations of time spent have been taken into record in order to measure workload and to detect free-riders. The "contamination" between traditional and PBL subgroups is inevitable when we work with a single group. In addition, we considered their random division into experimental and control subgroups unethical. For these reasons we decide to propose the PBL experience as a voluntary option. Then, the possible bias included by the voluntary factor should be carefully taken into consideration. However, and taking into account the null variance in contents, exam and instructors, we still can compare the condition of the whole group before and after the introduction of the PBL experience. An alternative study would consider only voluntary learners and organize randomized groups with them. As has been mentioned, students either know the required computer tools from previous courses or can learn them in specific laboratories. The whole group uses the LMS for accessing materials. The project subgroup uses some additional tools in order to consult and deliver tasks, but there is no essential difference in both subgroups from a learning point of view.

Furthermore, a survey instrument was generated. It focused on the construct as represented in the proposed research model (as shown in Figure 1). Ten items assisted to determine the phase of informational use and communicational LMS use. Items about announcements, document publishing, receiving assignments, the agenda, and learner tracking module are linked to informational LMS use. Items about the use of the chat environment, the discussion forum, assessment module, and learning paths are connected to communicational LMS use. Participants were asked to indicate on a five-point Likert scale to what extent they did actively use the particular LMS tool or functionality. Based on several previous researches (Chau and Hu, 2001; Dong, 2009; Venkatesh et al, 2003), we adopted the four-item performance expectancy scale for perception of utility and the four-item effort expectancy scale for perception of user interface. For subjective criterion, the two-item scale based on Armitage and Christian (2003) is used. Personal innovativeness toward IT is assessed with the four-item scale from Rosen (2004). Internal ICT support is based on the four-item scale by Tondeur, Valcke, et al. (2008). All of these items are measured on a five-point Likert-scale, ranging from “very disagree” (one score) to “very agree” (five score).

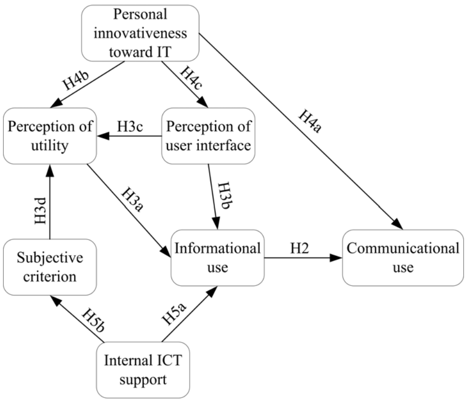

Figure 1: Proposed research model.

5 RESULTS AND DISCUSSION

5.1 Effects in Both Learning Methods

Table 1 compiles the data obtained comparing traditional and PBL methods in courses 2010 and 2011. Also means comparison tests or Person’s chi-square tests are included. The exam results correspond to the grade (from 0 to 10) obtained in the final exam of the course. The dropout rates were measured by the absence of mark in this exam. This exam was passed obtaining at least five points. Attendance of lectures and labs was not compelled. We controlled, however, the attendance of practical classes (15 in 2010 and 17 in 2011). Learners were informed that this control was only for statistical purpose. We find that attendance has a direct correlation with success in the exam ($r = 0.402$, $p < 0.05$). As shown in Table 2, the data allow us to identify a better attitude towards the course in the PBL group. We observe that participants of the project group obtained better exam grades, passed the exam, and attended more classes than their fellows of the traditional group in a significant way. The findings seem to support the hypothesis H1a.

Table 1: Results in PBL and traditional approach in 2010 and 2011.

	PBL group	**Traditional group**	**Statistical test**
Sample *N* (%)	116 (61)	73 (39)	
Grade Mean (SD)	6.47 (1.82)	5.06 (1.78)	t = - 4.579^a
Dropout rates %	7.3	21.85	χ^2 = 12.726, df = 1 ^{a}
Pass exam %	77.5	28.6	χ^2 = 35.143, df = 2 ^{a}
Attendance Mean (SD)	9.65 (3.85)	4.87 (3.92)	Z = -4.862^a

^{a} $p < 0.001$

The PBL experience was a bit different when we analyze each of the last two courses. The mean grade (SD) obtained in course 2010 by all members was 5.45 (2.10) whereas in 2011 it was 4.62 (1.82) ($t = -2.734$, $p < 0.05$). In 2010 the mean grade (SD) for the project-based group was 7.05 (1.46) and in the traditional method group it was 5.02 (1.74) ($t = -4.892$, $p < 0.001$). Nevertheless, in 2011 those data were 5.18 (1.62) and 4.48 (1.80), respectively ($t = -1.902$, $p = 0.076$). Although both courses showed better grades in PBL than in the traditional approach, in course 2010 only a trend to a statistical significant difference is observed. This means that the hypothesis H1a could be only partially supported. A long-term study may possibly illustrate if this current tendency is a permanent factor. Table 3 includes exam results and dropout rates gained from the whole group from 2008 to 2009 (traditional learning method) and from 2010 to 2011 (traditional and PBL). The class attendance has not been involved because it was not measured the first two years. From the introduction of the project-based method the results of the whole group have increased. Table 2 reveals better percentages of members that passed and took the exam than in previous courses. We can also appreciate certain improvement in exam grades, although not in a significant way. All these results seem to sustain the hypothesis H1b. If analyze each of the last two courses we obtain that is 2010, 35.1% of the members did not attend the exam and 39.8% passed it. These data were 33.8% and 26.3% in 2011, respectively. However, only the dropout rate maintains during the two last courses. There is not a clear tendency in exam grades. This means that the hypothesis H1b would be only partially supported.

Table 2: The results before and after PBL introduction.

	Group (2008– 2009)	**Group (2010– 2011)**	**Statistical test**
Sample *N* (%)	163 (46)	189 (54)	
Grade Mean (SD)	4.76 (2.36)	4.96 (2.12)	t = - 1.368
Dropout rates %	48.9	31.2	$\chi^2 = 14.648$, df = 1 [a]
Pass exam %	23.6	32.7	$\chi^2 = 8.256$, df = 2 [b]

[a] $p < 0.001$, [b] $p < 0.01$

To analyze the influence in traditional students of classmates following PBL, the first column of Table 1 and the first column of Table 2 should be considered. While there were no differences in the grade nor in the percentage of members who passed the exam, the dropout rate decreased ($\chi^2 = 4.925$, df = 1, $p < 0.05$). The project-based method influenced the traditional group, at least in the aspect of attending the exam (Keogh-Brown et al., 2007). Meanwhile, mean grades obtained by the traditional group before and after the introduction of the project-based method are essentially the same. From the last two ideas, more people participating with similar universal results, we can infer a positive overall success improvement in traditional learning students. Therefore, these results seem to support the hypothesis H1c. However, the mean mark remained flat throughout the four courses and decreases the last year although not in a significant way. This indicates that the hypothesis H1c could be only partially sustained.

Participants revealed to have spend a mean (SD) of 35 (11.6) hours of individual work developing the project, almost double the estimation (18 h). This reflects a negative aspect of PBL, a workload increase for both learners and instructors (Martínez & Duffing, 2007; Van den Bergh, et al., 2006). However, there are two interpretations of the estimated time. The PBL project viewpoint uses the task as a way to learn (constructing internal structures by discussing and understanding concepts, and so on). The software perspective assumes that an engineer will apply knowledge previously acquired to solve problems. The time scheduled corresponds to the second interpretation, whereas the time declared could include aspects related to the first aspect. These individual time declarations have not helped to identify the free-riders presence (Van den Bergh, et al., 2006). The coincidence in the spent time in all group members is probably due to the teamwork scheme. Obviously, all group members used to meet to fulfill their tasks collectively. Therefore, we have no idea of the level of contribution of each particular member from this data. Instructor workload has increased compared to the traditional method, although we did not systematically measure this item. The LMS has been revealed to be a very useful tool that significantly mitigates the work related to document, schedule, and communication management. In addition, students need quick feedback, especially in the first steps. The group tutorship and task feedback and assessment also increase the instructor workload. We have also identified other benefits of PBL that were not measured, including reflective thinking (more critical contributions, noticeable interest towards the subject topics, improved quality of questions, etc.), development of work skills (developing a full creative product design, fulfilling a set of rules and deadlines, and so on), and social skills (collaborating with the rest of the group members, unbroken teams, and so forth.).

5.2 Psychometric Quality of the Research Instrument

To examine the psychometric quality of the instrument section focusing on the identification of types of an LMS usage, a two-step validation procedure was adopted. The sample (*N* = 116) was divided into two sub-sample to evaluate the construct validity. We have used SPSS version 18 to conduct an exploratory factor analysis on the data of the first sub-sample (*n* = 56), using Maximum Likelihood estimation with oblique rotation. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.87, exceeding the suggested threshold for factor analysis of 0.6 (Manly, 2004). The Bartlett's test of sphericity was – as required – significant at 0.001 level. The number of factors was determined by a parallel analysis (O'Conner, 2000) and an examination of the scree-plot. On the basis of a first EFA, a two-factor solution was found, but two items (student tracking module and the agenda) were deleted due to communality values exceeding the threshold. A second EFA was performed on the 8 remaining items. A two-factor was performed on the nine remaining items. A two-factor solution emerged, accounting for 61.2% of the common variance among the items, with eigenvalues of 4.06 and 1.38. As illustrated in Table 3 and marked in italic and bold, two substantially different constructs can be distinguished and are in line with the findings of Hamuy and Galaz (2010). Releasing announcements, publishing document, uploading exercise and receiving student works can be considered as indicators of an informational phase in LMS usage. Learning path, chat, forum, assessment modules and social support can be marked as indicators of the communicational phase in LMS usage.

Table 3: Exploratory factor analysis of the dependent variables.

	Factor	
	Informational use	**Communicational use**
Releasing announcements	***0.952***	-0.0051
Publishing document	***0.725***	-0.022
Uploading exercises	***0.575***	0.176
Receiving student works	***0.480***	0.235
Learning path	-0.075	***0.802***
Chat	-0.122	***0.720***
Forum	0.185	***0.628***
Assessment modules	0.136	***0.572***
Social support	0.085	***0.526***

Next, AMOS (an add-on module for SPSS) was used to perform a confirmatory factor analysis (CFA) on the data of the second sub-sample (n = 60) and building on the two-factor structure resulting from EFA. The following indices were calculated, taking into account criteria for the evaluation of goodness-of-fit indices (Byrne, 2009): Chi-square/degrees of freedom is less than 3 (2.32), the root mean square error of approximation is higher than 0.05, but lower than 0.08, reflecting a reasonable fit. The comparative fit index (0.96), the normed fit index (0.94), and the Tucker-Lewis index (0.96) reflect good fit values since they are close to 0.95. To conclude, on the base of the EFA and CFA, we can report that the instrument to determine LMS use reflects good construct validity. Construct validity was evaluated for the other variable measured with the instrument. Exploratory factor analysis (n = 56) using Maximum Likelihood estimation with oblique rotation was performed. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.87, exceeding the suggested threshold for factor analysis of 0.6 (Manly, 2004). The Bartlett's test of sphericity was – as required – significant at 0.001 level. The number of resulting factors is in line with specific variables that were intended to be measured. All values are close to 0.85, exceeding the threshold value (Marcoulides & Raykov, 2011). Besides, correlations between all variables are listed. A correlation matrix approach was used; most values are low among the different constructs. All mentioned values suggest adequate validity of measurements.

5.3 Analysis of Research Model

As described earlier, the hypothetical relationships between the variables were tested on the base of structural equation modeling, using AMOS. The following fit indices were obtained. Chi-square/degree of freedom is slightly higher than 3 (3.05), the root mean square error of approximation is close to 0.05, suggesting a good fit. The comparative fit index (0.96), the normed fit index (0.92), and the Tucker-Lewis index (0.89) have value close to 0.9 or approach the benchmark of 0.95. All common goodness-of-fit indexes exceeded or approached their respective common acceptance levels, suggesting that the research model exhibited an acceptable fit with the data. Properties of the causal paths, including standardized path coefficients and p-values are shown in Figure 2.

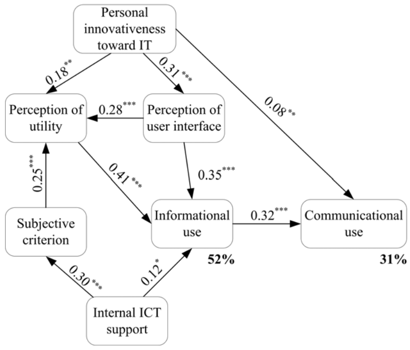

Figure 2: The result of research model testing.

As to the assumption that informational use can be considered as a precursor for communicational use (H2), this hypothesis was sustained ($\beta = 0.32$, $p < 0.001$). The traditional TAM elements appeared in four hypotheses. Perception of utility has a positive significant effect on informational use (H3a, $\beta = 0.41$, $p < 0.001$). Perception of user interface in a significant and positive way informational use (H3b, $\beta = 0.35$, $p < 0.001$) and perception of utility (H3c, $\beta = 0.28$, $p < 0.001$). Subjective criterion is found to be a significant factor in determining perception of utility (H3d, $\beta = 0.25$, $p < 0.001$). In line with other TAM studies, all hypotheses constituting the TAM-framework (H3a, H3b, H3c and H3d) are confirmed. The findings indicate that personal innovativeness toward IT has a direct positive effect on perception of utility (H4b, $\beta = 0.18$, $p < 0.01$) and on perception of user interface (H4c, $\beta = 0.31$, $p < 0.001$). The effect on communicational use is significant but rather weak (H4a, $\beta = 0.08$, $p < 0.01$). Hypotheses H5a and H5b postulated the impact of internal ICT support on informational use and subjective criterion. The analysis results show that internal ICT support has a positive significant effect on informational use (H5a, $\beta = 0.12$, $p < 0.05$) and a significant effect on subjective criterion (H5b, $\beta = 0.30$, $p < 0.001$). The whole model is able to explain 52% of the variance in formational use and 31% of the variance in communicational use.

In summary, the study contributes to the literature in a number of ways. Firstly, the use of

LMS by college students has been further explored and refined. Secondly, the study focused on the acceptance of the LMS by college students. Further, the operationalisation of an LMS use into informational use and communicational use appeared to be valid. The research model is able to explain 52% of the variance in informational use and 31% of the variance in communicational use. As hypothesized, informational use seems to be a precursor of communicational use. Meanwhile, we could successfully generate on perception of utility, user interface and subjective criterion as predictors from the original TAM-framework. Both perception of utility and perception of user interface were found to have a strong effect on informational use. This means that in order for a college student to use his LMS in informational way, the utility and user interface of the LMS will be both taken into consideration. However, since we found a significant effect of perception of user interface and subjective criterion on perception of utility, we can additionally postulate that the user interface of the LMS should be a critical initial variable, followed next by learners' perception of the system's performance.

Another finding is the direct effect from internal ICT support on informational use and on subjective criterion. This result implies that supporting learners at the school level will not directly influence personal use, but especially impact the opinion of important others. More important, as also indicated by Tondeur, van Keer, et al. (2008), the impact of internal ICT support suggests the school level variables are important to understand technology acceptation. The adoption of the variable internal ICT support makes the TAM model congruent with the real – school – world setting and conditions as requested by Sun and Zhang (2006) and Ong et al. (2004). Also important is the positive effect of personal innovativeness on perception of user interface. This reveals that innovative learners are more easily convinced about the user interface of the LMS. On the other hand, the impact of innovativeness on utility was low, meaning that being innovative does not automatically result in a positive belief about a system's performance. This is also confirmed by the impact of personal innovativeness toward IT on communicational use. Being innovative is clearly not enough to start using an LMS for communicational use. Based on the importance of the participant's perception of the user interface of their LMS and the availability of support, school manager or LMS coordinators can consider the following practical recommendations: (i) Introduction sessions can be considered and manuals provided. If applicable, a proper translation of the LMS to the native language of the learner and clarification on specific design characteristics should be foreseen. (ii) Some learners are not familiar with functionalities like the social support or the learning path module. Best practices, adaptive guides and easy access to support will definitely be valuable for the learner and might be that extra little thing to get them inspired.

6 CONCLUSIONS AND LIMITATIONS

The use of LMS with PBL approach has been suggested for creative product design learning as a more effective way for students to obtain the essential knowledge and skills. On the other hand the development of projects corresponds with the main activity of a graduate on Mechanical Engineering and Information Systems. This study presents an approach that integrates both perspectives of a project as a useful creative product design learning method that tries to overcome several problems of PBL applications. Our approach focuses on the development of projects where students, organized in groups, design and build real product. Certain scaffolding is offered to reduce both the project complexity and the uncertainly inherent in the beginning of the tasks, and also to motivate learners. Participants propose the project topics and the imposition of some constraints in the first task achieves the complexity balance control. The communication with end-users is emulated throughout role-playing between pairs of student groups. The computer is essential tool to put this method into practice, from the point of view both of the creative product design and task management. An LMS is a powerful solution in order to minimize the necessary effort to organize the information shown to the learners, group management, deliverable collection and communication with and among students. There are not many works about PBL effectiveness for creative product design learning. We have explored the results of two academic years using the proposed project-based learning approach. This quasi-experimental study shows that on the one hand, learners that follow this method obtain better results than members that follow a traditional learning method. And on the other hand, the introduction of such an approach in a student subgroup positively influences the whole group.

Furthermore, the purpose of this study was twofold: (i) developing a better understanding of college student acceptation of an LMS and (ii) investigating the way this group of students actually uses an LMS in their learning setting. Though the result, discussed above have clearly helped to attain our research aims, a number of limitations are to be considered. Firstly, instead of reported use of an LMS, we expect that using log files could lead to more accurate LMS related data. However this was not feasible practically in the current study, given the number of respondents and the difficulties in getting access to log files. Secondly, our study validates the categorization of LMS-interactions as defined by Hamuy and Galaz (2010). However, additional LMS functionalities, such student tracking module and the agenda had to be removed during the factor analysis process. Future research should continue to focus on the refining of LMS usage categories. Thirdly, we were able to explain 52% of the variance in informational use, but only 31% of the variance in communicational use. Further research should focus on identifying additional variables to explain the adoption and implementation of communicational use. The latter could be for instance linked to beliefs of instructors about the types of learning strategies that are linked to the adoption of these LMS functionalities.

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Authoring Storyline-based Adaptive 3D Virtual Learning Environments

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Abstract: Adaptive three-dimensional (3D) Virtual Leaning Environments are interesting for the e-learning domain as they have great potential resulting from the capabilities offered by 3D Virtual Environments in combination with the opportunities offered by adaptive systems. However, their breakthrough is hindered by the difficulty of their development. This paper presents a development approach that allows course authors to create adaptive 3D virtual learning environments without the need to be an expert in 3D or using programming or scripting languages. In particular, the paper elaborates on the principles used for the authoring approach, as well as on the different aspects that need to be supported, i.e. the pedagogical aspects, the adaptation aspects, and the requirement to support the specification of an adaptive storyline which should be followed by learners.

1 INTRODUCTION

3 dimensional (3D) virtual environments are defined as three-dimensional (3D), multisensory, immersive, real time, and interactive simulations of a space that can be experienced by users via three dimensional input and output devices (Burdea, 2006). This kind of environment is often used for entertainment, but can also be used in the context of education. For certain subjects and for certain types of learners using a 3D Virtual Learning Environment (3D VLE) may be much more appealing and motivating than the use of classical learning material, e.g., to simulate the effect of physical laws (Cobb et al., 1998); to simulate social environments and allow people to practice social skills (Adams et al., 2008); or to learn about history (Di Blas et al., 2003); Dede et al., 2003). Equipping those 3D VLE with adaptive capabilities could offer even more advantages (Chittaro and Ranon, 2007). For instance, adaptivity allows the 3D VLE to adapt dynamically (i.e. at run time) to the individual learner and to the progress that the learner makes during the learning process. It could mediate the distinction between education and entertainment, which could improve the learner's experience and motivate him better. Furthermore, adaptivity may be used to prevent the learner form being overwhelmed in the 3D VLE. For instance, it may be more effective to guide a learner through the 3D VLE according to his or her background and learning goals, or only show the learner the objects that are relevant for his current knowledge level, or adapt the environment to his learning style. Also adaptivity may be used to decrease the risk that learners are distracted too much and are therefore not able to focus on the actual learning task (De Troyer et al., 2010).

As the major goal of a 3D VLE is education, involving teachers or educational-schooled people is very important. However, with the current development tools for 3D virtual environments, it is very difficult to involve these people actively in the development process, as they usually don't have background in programming or in 3D. One way to overcome this drawback is to provide authors an authoring tool that enables them to turn existing 3D virtual environments into *adaptive* 3D virtual *learning* environments. With such a tool, the authors should be able to manipulate the 3D VLE contents to fit it to the context of the course and to the learners, and specify the required adaptive behaviour. The usability of such a tool will be a critical factor in its adoption.

Our work is based on the acquired experience in the context of a EU FP7 STREP project GRAPPLE

(GRAPPLE, 2008). It aimed at the construction of a generic adaptive learning environment that can be used/accessed at home, school, work, or on the move. GRAPPLE includes authoring tools that enable teachers to specify adaptation strategies for the contents and activities of their courses. The project considered classical learning materials, as well as simulations and virtual reality. Based on our experience in the GRAPPLE project, we found it is important to allow authors to provide a storyline for an adaptive 3D VLE that learners can follow during a course. This finding is supported by work done in the context of educational games, where narration helps the player to be more involved in the game and, as a result, to increase the expected learning outcomes (Salen and Zimmerman, 2003). Furthermore, narrative aspects can play an important role to deliver the instructional message and appropriate goals (Laurillard, 1998).

The rest of the paper is structured as follow. In section 2, we consider work related to authoring 3D environments in the context of e-learning and educational games. Section 3 explains the basics of adaptive 3D VLEs. In section 4, our authoring approach for adaptive 3D VLEs is explained, and section 5 proposes the architecture for the associated authoring tool. Section 6 presents conclusions.

2 RELATED WORK

This section reviews related work dealing with authoring adaptivity in 3D virtual learning environment and video games.

There exist different Virtual Reality (VR) development environments that enable advanced authors in VR to create 3D virtual learning applications. Some of them are specific for certain 3D virtual environments. Examples are (3Dxplorer®, 2002); (OpenQwaq, 2007); (Creator®, 2007). Another interesting example is the Sloodle project (Livingstone and Kemp, 2008) which is based on integrating learning and teaching across SecondLife (SecondLife, 2003) which is an online 3D virtual world, and Moodle (Moodle, 2002) which is a course management system. However, in the context of authoring tools to deliver adaptive 3D VLE, there is little available. For this reason, the related work mentioned in this section will also discuss narrative, adaptivity and authoring tools developed in the context of educational games.

An authoring toolkit called <e-adventure3D> is presented in (Torrente et al., 2008). The authoring tool has a scene editor that supports authors to define and configure size (width and depth), texture and roughness settings of the 3D virtual environments. Furthermore, the author is able to define the camera and lights settings, which will be considered as user guidance in the 3D virtual environment. The authoring tool also provides an editor to define the interactive elements inside the 3D virtual environments. The end-user will be able to interact with such predefined elements by carrying out some tasks and actions. Also the editor allows the author to place the interactive elements in a scene. Furthermore, the author can scale, rotate and/or translate them to fit correctly in the scene. Additionally, a 3D avatar representing the learner is available and which "*can engage in interactive conversations that can be graph-shaped if cycles are needed or tree-shaped otherwise. The editor includes a graphical facility to create these structures easily.*" (Torrente et al., 2008).

It should be noted that in <e-adventure3D>, game authors are not able to specify which kind of users interactions should be monitored, as this is limited to what has been implemented in the game API. Note that being able to monitor user interactions is important for being able to adapt the 3D virtual environment at run time. Another shortcoming is that adaptation resulted from monitoring the user interactions can only be performed in future execution of the game, not in real time. Furthermore, the authoring tool is used for only two predefined environments: closed environments and connected virtual rooms.

In (Marchiori et al., 2012), WEEV (Writing Environment for Educational Video games) is explicitly considering three elements or tasks to create narrative *point-and-click* educational games: (1) the author needs to define the actors, which are the interactive elements in the game. In other words, actors are the 3D objects upon which the player can perform an action and interact with them; (2) the virtual game world or so-called *gamespace* should also be defined. The virtual world includes the different interactive elements and non-interactive elements of the educational game; (3) the game story must be edited separately to define the player's interactions and the game feedback. The WEEV authoring tool is implemented as three editors to support the author in defining the main three elements: Simple Actor Editor, World Editor and Story editor. A domain specific visual language is used for the World and Story Editors. The Actors Editor enables authors to view a list of all the actors in the game in a specific panel. Furthermore, the author is able to select a new actor form a "resource library" containing different graphic resources. The World Editor allows the author to define the game world. On the other hand, the Story Editor is used to define the story-flow of adventure games. In general, a story is represented "…*based on a state-transition diagram, where each state represents a point in the game story and each transition an interaction by the user with the system, which moves the story along*." (Marchiori et al., 2012). The basic elements of the proposed game story flow language are: (a) *state* which represents the status of the game, (b) *transition* which is used to define a player action which moves the state of the game to next one, (c) *feedback* which is associated with the transition element to display effects or feedback when a transition happen. Furthermore, the proposed domain specific visual language provides specific features to integrate educational characteristics like content adaptation. For instance, the author can create an explicit representation of student assessment, hints for guidance and adaptation of the game story. Adaptation can be defined for the story-flow of the game depending on the student profile. The story-flow can have more than one initial state. The initial nodes of the story-flow are associated with different adaptation profiles in the game, for instance, "easy", "medium" and "hard" difficulty levels.

Researchers in (Gaffney et al., 2010) described an authoring tool (ACTSim) which is developed to allow educators with non-technical background authoring situational simulations. Situational simulation focuses on teaching learners how to perform targeted task (Alessi and Trollip, 2001). Their approach designs adaptation aspects in two ways. First, a tagging mechanism allows authors to define multiple properties for so-called adaptive dimensions (Wade, 2009) which include role of the learner, learning outcomes, categorization of the dialogue nodes and the related subjects. This is done by providing a highlight function in the authoring tool which allows the author to know how the dialogue model will be adapted. Secondly, triggers are used which allow the authors to define adaptation depending on educational principles of assessment, feedback and reflection. The ACTSim authoring tool supports the two approaches to design adaptive simulation. A good principle of the approach is not adhering the authors to compose complex rules in order to provide adaptation. An evaluation was conducted for the proposed authoring tool and the result was promising.

3 ADAPTIVE 3D VLE

In order to be able to discuss the principles used for our authoring approach, we first need to present the basics of adaptive 3D VLEs. First, we will discuss the different components that make up a 3D VLE. Next, we discuss the adaptation possibilities for 3D VLEs.

3.1 3D VLE Anatomy

Before we discuss how to drive adaptation for 3D VLE, it is important to know what are the 3D VLE components on which adaptation can happen. Conceptually, we can distinguish the following components and associated functionality in a 3D Virtual (Learning) Environment: (1) The *virtual scene* that corresponds to the 3D space which will be populated with the 3D virtual objects. (2) *Virtual objects* are objects which have a visual representation having colour and material properties, a size, a position in the space, and an orientation. (3) *Object behaviours* that are the behaviours associated to the virtual objects. Behaviours may reflect real life behaviours like rotation, walking, etc. (4) *User interactions* as users are able to interact with the virtual objects. For example, a user may pick up an object and drag it to some other place in the space (if the object is moveable). (5) *User navigation* which is related to the way the user can move in the 3D space, e.g., walking, running or flying. The user navigates by a so-called avatar. The user's avatar can be represented explicitly (by an object) or implicitly in which case the viewpoint of the camera is used to show the user's position. (6) *Communication* as nowadays, more and more 3D virtual environments are also collaborative environments in which remote users can interact with each other, e.g., talk or chat to each other or perform activities together. In this research, we concentrate on single-user environments. (7) *Sound* can be important component in simulations to enhance the feeling of reality or simply to simulate some sound. Sound/speech can also be used as an instruction and feedback mechanism during the learning process. More explanation about 3D VLE components is presented in (De Troyer et al., 2010) and (Kipper and Palmer, 2000); (Bowman and Hodges, 1999).

3.2 Possible Adaptation Techniques for 3D VLE

Different adaptation techniques and mechanism are proposed to be applied to 3D virtual objects. For instance, the work presented in (Chittaro and Ranon, 2007) presents adaptation techniques which are basically limited to 3D contents representations. On the other hand, the authors in (Dos Santos and Osório, 2004) propose the so-called Intelligent Virtual Agent to provide adaptive navigation towards interesting 3D virtual objects. However, adaptation can be applied beyond 3D material representation or user navigation. In principle, adaptation can happen for each component of a 3D VLE. An adaptation can be limited to a single component of the 3D VLE, but it can also involve different components of the 3D VLE. We defined two different adaptation categories (De Troyer et al., 2010). The first category includes adaptations that apply on a single component, i.e. possible adaptations for objects, behaviours, interaction, and for navigation. We call these *adaptation types*. For instance, there are adaptation types related to 3D virtual objects such as *semi-display, changeSize, changeMaterialProperties*, *changeVRRepresentation*, etc. For the moment, we did not consider any adaptations types yet for the scene or sound. Communication is also not considered because we focus on single-user 3D VLEs. The second category is related to more high-level adaptations that involve more than one component. These kinds of adaptations we called *adaptation strategies*. For instance, adaptation strategies that can be applied to group of 3D virtual objects are *filterObjects, markObjects, displayAtMost, displayAfter,* etc. More examples about adaptation types and strategies can be found in (De Troyer et al., 2010).

4 AUTHORING AN ADAPTIVE 3D VLE

In general, the purpose of an authoring tool is to enable authors defining a course at a high level of abstraction and without resorting to programming or scripting languages. In the same way, the purpose of our authoring tool is to allow authors to define an adaptive 3D VLE without the need to be experienced in 3D/VR and to know programming languages. In principle, this involves authoring the 3D virtual environment, as well as the adaptivity and the pedagogically relevant aspects of the course. We will not consider the authoring of the 3D virtual environment itself, as for this many tools are available (e.g., Google SketchUp (GoogleSketchUp, 2000)), 3D Studio Max (Murdock, 2003)). The purpose of our authoring is to add storyline, adaptivity and pedagogical aspects to an existing 3D virtual environment.

The approach taken for adaptivity is an author-driven approach which means that during the design of the adaptive course, the author needs to specify explicitly when and how the content needs to be adapted. The advantage of this is that it gives the control to the author. On the other hand, the disadvantage is that it requires the author to keep track, at design time, of all possible adaptation scenarios. However, we believe that supporting authors with appropriated tools can overcome this disadvantage.

In the following sections, we first present the (high level) requirements that we formulated for our authoring approach. Next, we discuss the models and principles used for the authoring approach. Finally, we provide more details on the three most important steps of the authoring process.

4.1 Requirements

Based on our previous work done in the context of the GRAPPLE project, we derived some important features to be considered in authoring adaptive and educational 3D virtual environments. The most important features can be summarized as follows:

- *Pedagogical-oriented:* As we are dealing with 3D virtual *learning* environments, we want to provide means to take into consideration some pedagogical aspects when specifying an adaptive 3D VLE (i.e. the course). This is achieved by enabling authors to create pedagogical relations between the different learning concepts.
- *Adaptive-specific*: As we are dealing with *adaptive* 3D virtual learning environments, we want to provide means to specify the adaptivity of a 3D VLE using a high level of abstraction. The idea is to provide a number of different (pre-defined) adaptation types and strategies to allow the author to express the adaptivity.
- *Teacher-oriented*: One of the major goals is allowing teachers and pedagogically schooled people to be directly involved in the authoring process of the adaptive 3D VLE. This requires that the authoring approach should be at a high level of abstraction, and using terminology that is understandable by this type of users.
- *Storyline-oriented*: We have observed (during evaluations performed in the context of the GRAPPLE project (Ewais and De Troyer, 2014))

that when using a 3D VLE, there is a need to guide the learners through the learning material offered in the 3D VLE in a way similar as this is done for classical text-based learning material (where some kind of sequence is enforced or advised). For instance, the author may want to express that the learners first should get a guided tour through the virtual environment highlighting the most important learning objects, next they should focus on performing some activities related to one learning concept, and so on. However, while for classical learning material a personalized "sequence" could be achieved by specifying adaptation rules only, our previous work done in the context of the GRAPPLE project has shown that this is very difficult to be achieved for 3D VLEs only with the use of adaptation rules. To allow expressing such a "sequence", we will use the concept of *storyline* (taken from game development).

- *Web-based:* A web-based authoring tool will allow easy access to the tool independent of the platforms or PCs that are used by the authors.

4.2 Models & Principles

In general, classical adaptive systems maintain different kinds of information in different models (Paramythis and Loidl-Reisinger, 2003). We also follow such an approach. Authoring an adaptive 3D VLE goes as follows. First a *Domain Model* (DM) (Hendrix et al., 2008) describing the concepts that should be considered in the course, needs to be created. Learning resources and materials are associated with these learning concepts.

We also use a *User Model* (UM), which is used to maintain the learner's characteristics, learning background, and his learning progress.

Next, pedagogical relationship types should be defined between the different learning concepts. An example of a pedagogical relationship type is the prerequisite relation that expresses that one concept is a prerequisite to master the other concept. These pedagogical relationships are defined in the *Pedagogical Model* (PM). The PM also expresses at a high-level how the User Model should be updated (at runtime) based on what the learner does in the learning environment. After that, the author defines the actual adaptivity behaviours (*Adaptation Model*) for the 3D VLE. For this a rule mechanism is used. Adaptation rules are basically if-then rules. The if-part specifies the conditions to be satisfied for performing the adaptation, while the then-part specifies the adaptation actions. These adaptation actions are expressed in terms of the adaptation types and strategies (see section 3.2) to be performed on the 3D VLE components. In our approach, the adaptation rules are defined in context of two sub-models: *Adaptive Storyline Model* (ASLM) and *Adaptive Topic Model* (ATM). We first explain the purpose of these two models.

As indicated in section 4.1, to define the actual course, the author will use a storyline. This storyline defines the steps that the learner should follow during his learning process. The storyline can be adaptive, i.e. the actual flow can adapt at runtime e.g., depending on the learner's knowledge about specific concepts. The storyline and how it should adapt is defined in the Adaptive Storyline Model. A storyline consists of number of *topics*; each topic is dealing with a number of 3D virtual objects. The topics are connected with so-called *storyline adaptation rules*. These adaptation rules specify the adaptive behaviour of the storyline. Figure 1 depicts the sub models in the adaptation model.

Next to the adaptivity expressed for the storyline, more adaptivity can be expressed for the topics. A topic is defined by means of an Adaptive Topic Model. In this model, the 3D virtual objects involved in the topic are specified, as well as the actual adaptation actions that have to be applied to them. Moreover, it specifies when the adaptions need to be applied. Also here, a rule mechanism is used.

In the rules, the conditions are not only based on the learner's preferences or learning background and learning progress (maintained in the User Model) but also on the activities performed by the learner in the 3D VLE (e.g., number of interactions with a certain object, the behaviours performed). This type of information, which may not always be directly related to the learning, is added to be able to control the learner's behaviour in the 3D VLE, e.g., to avoid that he wastes too much time by playing around or to help him when he has problems in navigation or interacting with objects. This information is stored in the so-called *3D VLE Activity History Model*. It is important to mention that not all the user activities inside the 3D VLE are monitored. But the more information is kept about the activities of the learner in the 3D VLE, the more this information can be taken into account to adapt the 3D VLE to the individual learner. Note that some data from this 3D VLE Activity History need to be translated into User Model data. For instance, it needs to be defined what activities need to be performed in the 3D VLE by the learner to raise the knowledge level of a certain learning concept.

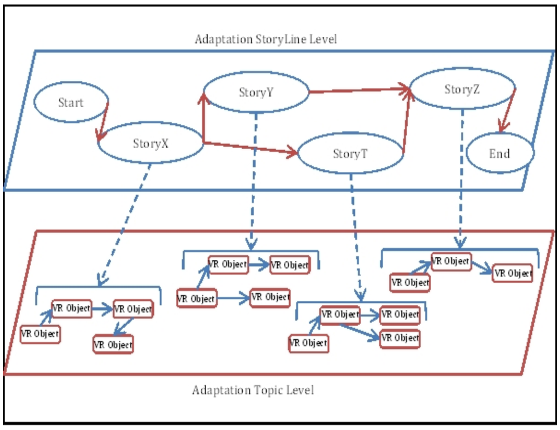


Figure 1: Two-level specification of the Adaptation Model.

Maintaining the User Model and the 3D VLE Activity History at runtime is done by the adaptive delivery environment. Figure 2 depicts the different models used in our approach to perform the adaptation process inside a 3D VLE and how they are related to the authoring process, respectively the adaptive delivery process. It is actually the Adaptive Engine that will figure out when to use which adaptation rule. It is also the Adaptation Engine that sends updating instructions that are related to the User Model according to user activities performed inside the 3D VLE. The Adaptive Engine is also responsible for selecting the appropriated 3D resources (based on the adaptation rules) and sending them to the delivery environment (client side). Actually, the exact content of the course is composed on the fly by the Adaptation Engine.

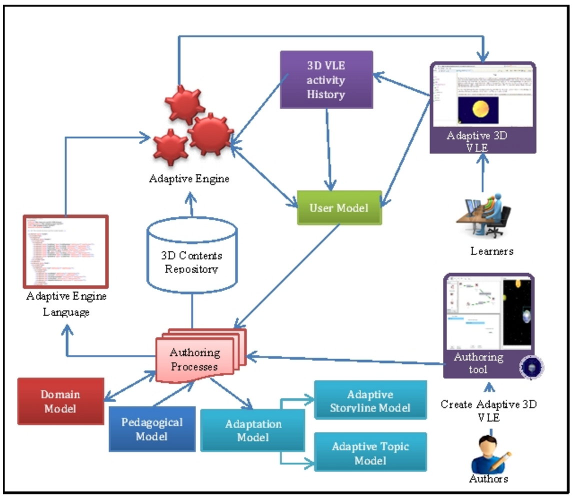


Figure 2: Conceptual Framework for Adaptive 3D VLE.

In the next three sections, we will elaborate on the three most important aspects of the authoring process, i.e. authoring the Pedagogical Model, the Adaptive Storyline Model, and the Adaptive Topic Model.

4.3 Authoring Pedagogical Aspects

The Pedagogical Model (PM) is used to define the pedagogical structure of the learning concepts, as well as to indicate how the learner's knowledge (captured in the User Model) should be updated based on the learner's activities inside the 3D VLE.

A typical *Pedagogical Relationship Type* (PRT) is the *prerequisite*. When a learning concept A is a prerequisite for learning concepts B, this means that the learner needs to study concept A before he can start with concept B. Other PRTs like *Defines, Illustrates, Interest, Propagates_knowledge* and *Update_knowledge* can also be used to define relationships between the different learning concepts.

After defining Pedagogical Relationships Types between learning concepts, the author can specify the *Pedagogical Updating Rule* (PUR) for each PRT. PURs are responsible for defining how the User Model needs to be updated based on the activities performed by the learner. PURs are *condition-action* rules. At runtime, the PURs are triggered on accessing (visiting) learning concepts. The action part of a PUR defines the updates that will happen. For instance, the *interest*-PRT has a PUR that for visiting a 3D learning concept will update the user's interest level of the target 3D learning concept. The following is an example of Pedagogical Updating Rule associated to the *interest*-PRT:

```
IF    (UserID.3DLearningConceptA.
knowledge = 'GOOD')

THEN  (UserID.3DLearningConceptB.
interest= 'HIGH')
```

Note that, rather than requiring the authors to specify the learning sequence for the learning concepts in all possible cases, the authors only have to provide the PRTs between the different learning concepts and the adaptive engine will be able to dynamically derive the required learning sequence.

4.4 Authoring Storyline Adaptation

As already explained, an adaptive storyline enables the delivering of the topics in an adaptive sequence. To achieve this, *storyline adaptation rules* are used. A storyline adaptation rule is associated with a topic, the source topic, and is used to control the transition to the next topic, the target topic. Such a rule consists of two parts: a *condition* part and an *action* part. The condition part is used to specify when the learner can be directed from the current topic (the source topic) to the next topic (the target topic). The condition is, in general, based on two aspects: the learner's current knowledge level about the current topic and the suitability of the next topic for the learner. To simplify tracking the learner's knowledge and topic suitability, every topic in the storyline has two parameters: *topic knowledge* and *suitability*. A learner can acquire knowledge about the topic in a topic by navigating and interacting with the 3D objects (concepts) related to the topic. The knowledge level about the topic is incrementally increased by acquired knowledge about the related concepts. The author needs to define how the topic's knowledge level can be increased. Once the learner's knowledge about the current topic crosses the specified threshold (given in the condition part of the rule) and the target topic is suitable for the learner then the learner will be able to progress to the target topic. This is specified in the condition part of the topic adaptation rule. For instance, in this way, the author can specify that a beginner should not be able to go to a topic for advanced learners.

In the action part of the storyline adaptation rules, the author specifies the adaptation strategies (see section 3.2) that should be applied on 3D virtual objects (learning concepts) of the target topic. For example, the author could specify the *interactionAtMost* adaptation strategy in the action part of a storyline adaptation rule to specify the maximum number of times the learner can interact with the 3D virtual objects (concepts) inside the target topic.

Let us illustrate the adaptive storyline by the following example. An author creates TopicX, TopicY, TopicZ, TopicR, and TopicT. Those topics consider the different issues to be discussed in the course. Every topic should include a number of learning concepts. The author can determine that learners with basic knowledge (beginners) should follow a larger number of topics than the learners with good knowledge (advanced). For instance, two possible storylines are envisaged. An advanced learner should have the following flow of topics: Topic X-> Topic Y -> Topic Z. After having completed topic Z, he will finish the course. On the other hand, learners with beginner level should follow a larger number of topics, as they need to master more concepts in order to master the topic: Topic X-> Topic Y-> Topic T-> Topic Z. In the same way as reading a course book, students with advanced knowledge can skip sections or even chapters. To realise this, the following topic adaptation rule can be associated with Topic X:

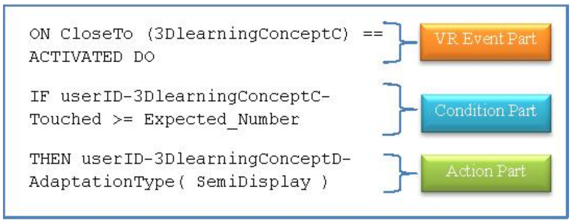
```
IF(user.TopicX.knowledge>
Required_Value)&&
(user.TopicY.suitability=TRUE)
THEN  navigationWithRestrictedBehaviour
<ConceptA,ConceptB,ConceptC>
<disableRotationBehaviour>
```

This rule states that the learner can progress from TopicX to TopicY when his knowledge about TopicX is above "Required_Value" (defined by the author) and his suitability for TopicY is TRUE. In addition, the action part specifies that in TopicY, the user can navigate through the environment but he will not be able to see rotation behaviours that are related to the ConceptA, ConceptB , and ConceptC.

4.5 Authoring Topic Adaptation

Inside a topic, the author can specify when and how the content and structure of the 3D VLE needs to be adapted. This is done using adaptation rules. For instance, the author can define an adaptation rule to change a 3D virtual object's properties based on the learner's activities inside the 3D VLE. To achieve that, an *event-condition-action* rule mechanism is used. The event-part is related to specific events related to the user's activities inside the 3D VLE, e.g., interaction with a 3D virtual object by mouse clicks or navigating close to a 3D virtual object. The event-part will be responsible for triggering the rule, but the condition-part must be satisfied in order to actually perform the action-part of the rule. The condition-part can deal with the learner's preferences, his learning background, and progress but also with previous activities performed by the learner in the 3D VLE. These last types of conditions are added to be able to control the learner's behaviour in the 3D VLE, e.g., to avoid that the learner wastes too much time by playing around. The following is an example of such a rule.

As an example, we explain an adaptation topic rule called *SemiDisplay3DObject* between Concept C and Concept D (see Figure 3). This rule will be evaluated once the learner comes close to (the 3D virtual representation of) concept C. As a result, the condition part of the rule will be evaluated which is in this case related to 3D VLE Activity History. Remember that the condition part can refer to user activities history inside the 3D VLE but also to his preferences, knowledge level, etc. If the condition part is true, then the so-called *semidisplay* adaptation type will be applied to concept D.



```
ON CloseTo (3DlearningConceptC) ==
ACTIVATED DO

IF userID-3DlearningConceptC-
Touched >= Expected_Number

THEN userID-3DlearningConceptD-
AdaptationType( SemiDisplay )
```

Figure 3: SemiDisplay3DObject adaptation topic rule.

Such a rule could be defined to draw the learner's attention to another 3D object instead of wasting his time by interacting with one single 3D virtual object.

5 ADAPTIVE 3D VLE AUTHORING TOOL: ARCHITECTURE

In this section, we present the architecture of the authoring tool. The main modules are shown in Figure 4. The *Web services toolkit* allows the authoring tool to connect with other external models such as the User Model and the Domain Model. Moreover, it allows the author to use local and/or external 3D modelling repositories used to store 3D materials and resources.

The actual interface to the user (i.e. author) is composed of two sub-environments. The *Data Models Environment* facilitates the preparation process for the required data models in the authoring process. The other sub-environment is called the *Pedagogical and Storyline Visual Environment* and provides access to three editors, which use visual languages to define respectively the Pedagogical Model, the Adaptive Storyline Model and the Adaptive Topic Model. Every sub-environment has different editor tools which are linked together using a unified user interface style. Furthermore, a Visualization Tool (previewer) is integrated in the authoring environment to allow authors to preview 3D VLE and to display actual effects of customized adaptation types and strategies upon 3D VLE components.

The Data Model Environment is composed of five editor tools: the *Pedagogical Relationship type Editor* to define PRTs; the *3D Learning Object Editor* to specify the required 3D learning objects; the *3D Adaptation States Editor* to create or modify adaptation types and adaptation strategies that will be applied to 3D objects; the *3D Learning Materials Editor* to associate adaptation types and strategies to specific 3D learning objects; and the *VR Events Editor* to define or customize the VR events specifications (for instance, the proximity area for the '*close to*'-event can be set/changed with the VR Events editor). It is important to note that these editors are targeted to more VR experienced users. Novice authors only need to use the *3D Learning Materials Editor* to indicate which 3D objects they will use. The other editors in this environment are needed to specify more details related to PRTs, 3D virtual objects, adaptation types and strategies, and VR events. But in general, defaults can be used. The resulting data models are the input for the Pedagogical and Storyline Environment.

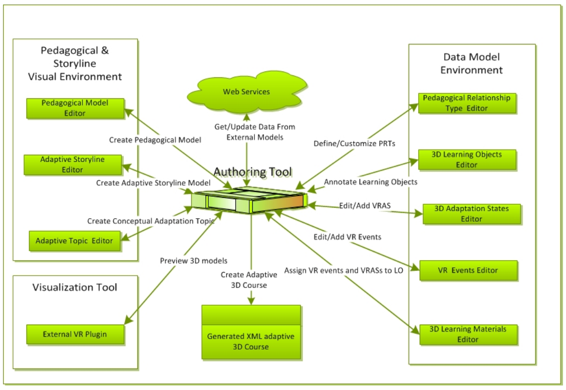


Figure 4: Overview of the 3D VLE authoring tool Architecture.

The Pedagogical and Storyline Environment has three visual editors, which are the *Pedagogical Model Editor*, the *Adaptive Storyline Editor* and *Adaptive Topic Editor*. We have opted for visual modelling languages, as our authoring tool is teacher-oriented and should be accessible by novice authors. The languages themselves will be described elsewhere.

Based on all information entered, the authoring tool can generate a 3D course in an XML format that can be parsed by an adaptive engine like AHA! (De Bra et al., 2003) or the adaptive engine used in the GRAPPLE project. However, this XML file can also be translated by means of XSL and XSLT into some other format.

6 CONCLUSIONS

Adaptive 3D virtual learning environments offer many advantages for learning. However, their breakthrough is impeded by the lack of authoring tools. In this paper, we have presented an authoring approach and associated tool architecture for these kinds of virtual learning environments. The approach and tool is based on experience obtained from our work done in the GRAPPLE project.

The approach is based on a number of principles that have been discussed in the paper. We have mentioned the different components of a 3D virtual learning environment and discussed how they can be adapted for satisfying the needs of a learner. We have motivated the need for a pedagogical component in the authoring process, as well as the need for a storyline-based authoring approach. The first requirement is achieved by enabling authors to define pedagogical relationships between the different learning concepts. To satisfy the second requirement, they are able to define a storyline inside the 3D VLE using a 2-layer approach. Adaptation rules can be associated with both layers, in each layer focussing on a different level of adaptation.

We are currently working on developing a prototype for the authoring tool. Furthermore, an empirical evaluation will be considered to validate the usability aspects of the authoring tool.

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ExperD: Web-based Support for Laboratory Class Workflow Design and Execution

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Keywords: Laboratory Class, Electronic Performance Support, Web-based.

Abstract: The design, use, and evaluation of a web-based experiment designer, ExperD, are described. ExperD supports students in designing a research strategy for their laboratory class. Next, ExperD supports students in their actual laboratory class work by showing them which experiments they have to carry out, and what the relation is between experiments. The use of ExperD was evaluated in the 2009 and 2011 editions of a Food Chemistry course at Wageningen University in The Netherlands. The evaluations showed that students (n = 60 and 98) find ExperD helpful and that teachers see the ExperD as a valuable addition to the laboratory class. Usage logs show that students used the tool throughout the entire laboratory class. Furthermore, the ExperD proved to be a promising research tool for monitoring both student design activities as well as student actual lab work activities.

1 INTRODUCTION

Laboratory classes are an essential part of chemistry education. With respect to the work presented in this article, we focus on two challenges in laboratory class education. Firstly, skills related to designing experiments are often undertrained in laboratory classes (Bennet and O'Neale, 1998; Domin, 1999). Secondly, students can experience working memory overload in laboratory classes (Johnstone, 1997). If a problem requires the learner to have too many chunks of information in his or her working memory simultaneously, this memory becomes 'overloaded'. Working memory overload hampers both the problem solving process and learning (Kirschner 2002; Sweller et al., 1998). In practice, this will lead to less effective and less efficient laboratory classes (Johnstone, 1997). These two challenges were also recognized in the B.Sc. 'Food Chemistry' laboratory class at the Wageningen University. In the remainder of this article we first describe this laboratory class in more detail, followed by the aim and methodology of the research presented here. Next, we describe the web-based design tool ExperD and two case studies in which ExperD was evaluated. Finally, we discuss the results of this evaluation.

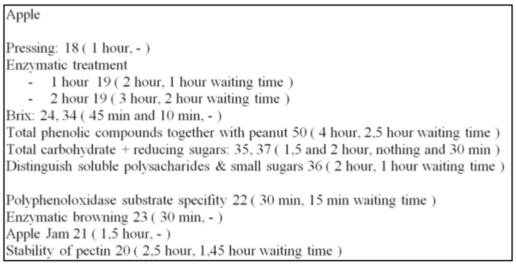
1.1 The B.Sc. 'Food Chemistry' Laboratory Class

The eight week morning course 'Food Chemistry' (6 ECTS credits) at Wageningen University in the Netherlands consists of four parts. In the first three weeks students attend lectures, practice the theory using digital exercises and perform self-study. The next three weeks are spent in a laboratory class. Next a self-study week is scheduled followed by an exam in the 8th week of the course. During the laboratory class students should:

- Learn to work together in small groups.
- Acquire hands-on experience with common food chemistry research methods.
- Learn to design a research strategy.

Students work in small groups of 2-3 students. Each group is given an agricultural material (e.g. barley) and investigates major chemical changes during simulated processing (e.g. beer brewing) during the 3 weeks. For example, in the case of barley, groups mimic the first steps in beer brewing on a bench scale and are asked to investigate what happens to the major carbohydrates and proteins. Groups are guided through the investigation by 15-19 assignments. They design their research strategy by relating these assignments to common food chemistry experiments. There is a many-to-many relationship between assignments and experiments: Assignments relate to multiple experiments and experiments relate to multiple assignments. Assignments as well as experiments can take more than one day to complete. The groups should make a time schedule of their laboratory work and distribute tasks among group members. Once a group has completed the formulation of their research strategy they have to present their set-up to a teacher. The teacher provides feedback such as pointers to inconsistencies or inefficiencies.

In general, teachers of the Food Chemistry laboratory class were not satisfied with the research strategies student groups came up with. Many groups made unclear designs, others just made a list of experiments and assignment numbers (see Figure 1).



Apple

Pressing: 18 (1 hour, -)
Enzymatic treatment
- 1 hour 19 (2 hour, 1 hour waiting time)
- 2 hour 19 (3 hour, 2 hour waiting time)

Brix: 24, 34 (45 min and 10 min, -)
Total phenolic compounds together with peanut 50 (4 hour, 2,5 hour waiting time)
Total carbohydrate + reducing sugars: 35, 37 (1,5 and 2 hour, nothing and 30 min)
Distinguish soluble polysacharides & small sugars 36 (2 hour, 1 hour waiting time)

Polyphenoloxidase substrate specifity 22 (30 min, 15 min waiting time)
Enzymatic browning 23 (30 min, -)
Apple Jam 21 (1,5 hour, -)
Stability of pectin 20 (2,5 hour, 1,45 hour waiting time)

Figure 1: Example of research strategy design made by students.

As a consequence of the unclear designs, teachers often had to spend quite some time on figuring out what students meant, and felt it was difficult to give sufficient adequate feedback. In defense of the students it can be argued that they did not receive training nor guidance in making clear research strategies. We therefore felt that there was an opportunity to improve the laboratory class by offering students support in designing research strategies.

Teachers also observed that the majority of the students were ‘just carrying out a list of experiments’ during the laboratory class. So most students did not know why they were carrying out a particular experiment, nor the relation of that particular experiment with the research strategy as a whole. With (Johnstone, 1997) we attribute this behavior - at least partly - to an overloading of working memory. We further hypothesize that this overloading was related to the research strategies that they had designed and in particular to the chaotic nature of the formulation of these strategies. This reinforced our belief that offering support in making a clear research strategy could improve the laboratory class.

1.2 Aim of this Research

The aim of this design oriented research was to address the opportunity described in the above section. As workflows of experiments are not an uncommon format for food chemists to present their research strategies, e.g. (Christiaens et al., 2012; De Roeck et al., 2008; Chassaigne et al., 2007), the basic idea was to provide a web based tool that would support students in designing a workflow of experiments. Teacher-student and student-student interactions could then benefit from the standardized representation of the workflow designs. Additionally, the workflow could function as a scaffold during laboratory work, as it would give students a clear view on the relation between experiments and insight in their progress. To our knowledge, such a tool for chemistry laboratory classes does not exist yet.

The following research question was leading during the research: Is it possible to design, realize and implement a web based experiment workflow design tool that

1. students find helpful?
2. teachers find valuable?
3. students really use during the laboratory class?
4. serves as a research tool for monitoring student design activities and student progress during the laboratory class?

1.3 Research Method

Design oriented research aims at the generation of knowledge by designing a new artefact (Busstra, 2008; Österle et al., 2010). This model focusses on sharing knowledge with respect to sensible goals in a well specified real university context, providing arguments why these goals make sense and demonstrating how they can be achieved in that context (Hartog et al., 2010). The goals are formulated in terms of testable design requirements, which are used to evaluate the realized and implemented artefact (Verschuren and Hartog 2005). For the design we chose the satisficing strategy, a strategy that tries “to meet criteria for adequacy, rather than identifying an optimal solution” (Jonassen, 2008) Our design requirements are listed in Table 1. From now on we will refer to the realized design by its name 'ExperD'.

The ExperD would have to be implemented in an existing educational setting. This implied that it should fit the existing infrastructure and some already available web based resources. In particular,

Table 1: ExperD design requirements. Evaluation questions use a five-point Likert scale (1 = agree, 5 = disagree) for response. Our satisficing criterion is that we consider the design requirements to be met when at least 80% of the students rate an item as 4 or 5.

Design requirement	How to determine whether the design requirement is met.
r1. According to the students ExperD should be helpful a. in general	Student questionnaire questions/statements: q1. "I found it useful to design a scheme." q2. "I would like to have such an ExperD in other laboratory classes."
b. in order to work efficiently	q5. "The ExperD helped our group to work efficiently."
c. by giving them the overview	q6. "The ExperD helped me to figure out what I could expect during the laboratory class." q7. "The ExperD helped me to have the overview during the laboratory class."
d. by being easy to use	q3. "The ExperD was easy to use." q4. "The ExperD was self-explanatory." q8. "It was easy to distribute tasks using the ExperD's user interface"
r2. Be really used by groups during their practical work	Usage logging: 80% of the groups should be updating their experimental workflow during the first two weeks of the laboratory class.
r3. Be appreciated by the teachers.	Teacher interviews
r4. Serve as a monitoring tool for design activities.	Teacher interviews / Usage logging

ExperD would make use of desktop computers that are present on the student laboratory benches. Moreover, ExperD should become part of the content management system Drupal™ 6, which is used by the Laboratory of Food Chemistry to deliver and manage their e-learning resources. Thirdly, the ExperD should be integrated with the web based laboratory manual developed earlier (Kolk et al., 2011).

1.4 ExperD

Taking into account the design requirements from Table 1 and a set of design and usability recommendations (Mayer, 2009), a web-based environment for the design of an experimental workflow (ExperD) was realized. The user interface of the ExperD consists of five main elements: 1) a main bar with available experiments, 2) a workflow view containing 3) one or more experiments, 4) a dialog window to edit the properties of the selected experiment (Figure 2) and 5) a time planner (Figure 6). These user interface elements can be configured depending on the characteristics of the course. In the remainder of this section ExperD's user interface elements will be discussed as they were configured for the course 'Food Chemistry'.

With ExperD, students design a research strategy in the form of a workflow of experiments. In the 'Food Chemistry' course, they do this by choosing one of the assignments from the available experiments and adding the appropriate experiments to the workflow (Figures 3 and 4). Students connect those experiments of which samples should be transferred from one experiment to the next. For example: They connect the experiment 'Get starch solution' to the experiment 'Hydrolyze starch with enzymes' because the sample obtained in the former experiment is used in the latter experiment. Next, students describe the sample in chemical/physical terms by selecting one or more properties from a list with properties (see Figure 5). For example: Does the sample contain carbohydrates, fats, proteins; is the sample solid or liquid? To support the design process, the ExperD gives feedback on the properties selected by the students. For example: the experiment 'Grind sample' does not expect a liquid sample, so if students try to connect an experiment to 'Grind sample' having a liquid sample, the ExperD gives a warning message (Figure 3). Because the feedback is based on the properties of the ingoing samples – and not on the upstream experiments providing these samples – teachers do not have to adjust the feedback of existing experiments when they add or remove experiments. Besides describing the sample properties, students can enter other data for each experiment.

They can enter for what assignments/research questions they need the experiment, what the experiment's purpose is, which group member is going to carry out the method, what the results are and when the method will be carried out. The scheduling of methods is done in a 'Gantt chart' like manner (Figure 6): Students drag and drop, stretch and shrink the experiments on a horizontal time axis to obtain a time planning. Lastly, an experiment in the ExperD can be linked (Figure 7) to a learning object in a web based laboratory manual (Kolk et al., 2011).

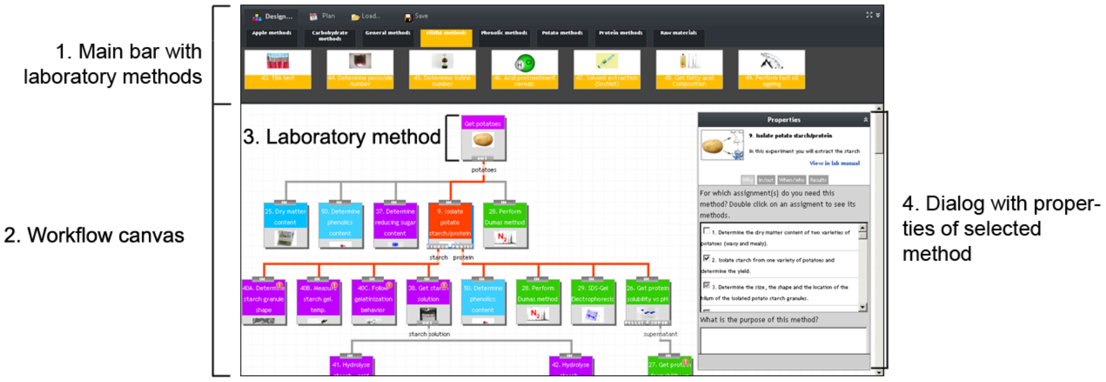


Figure 2: Overview of the ExperD's user interface. Students design their experimental workflow by selecting experiments from the Main bar (1). The experiments (3) are added to the Workflow canvas (2) and students can connect them, or change their properties using a dialog (4).

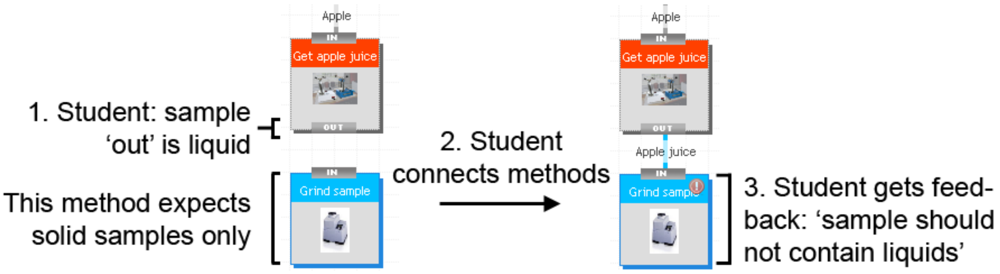


Figure 3: The ExperD's feedback system is based on the student-defined properties of the samples going from one method to another.

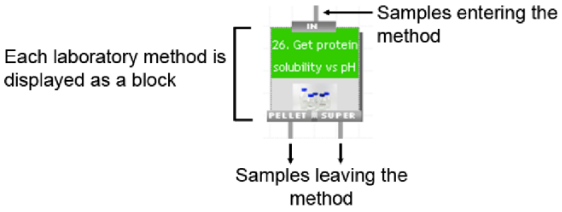
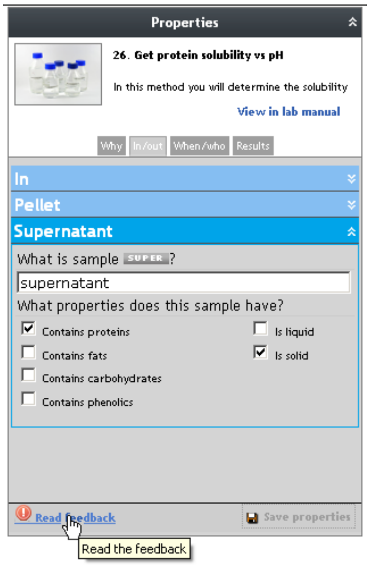


Figure 4: An experiment in the ExperD is displayed as a block with ingoing and outgoing samples. For example: the experiment 'Get protein solubility vs pH' has one ingoing sample 'In' and two outgoing samples 'Pellet' and 'Supernatant'.



26. Get protein solubility vs pH

In this method you will determine the solubility

View in lab manual

What is sample SUPER ?

supernatant

What properties does this sample have?

☑ Contains proteins ☐ Is liquid
☐ Contains fats ☑ Is solid
☐ Contains carbohydrates
☐ Contains phenolics

Figure 5: The properties dialog as configured in the course 'Food Chemistry'. In this dialog students can view/edit the properties of the selected experiment.

1.5 Two Case Studies

The ExperD was implemented and evaluated in the 2009/2010 (further referred to as '2009') and 2011/2012 ('2011') editions of the course 'Food Chemistry'. The set-up of the laboratory class did not significantly change between these two editions. There were differences between the versions of the ExperD software used. The version of ExperD that was used in 2009 did not yet include a time planning module. This came only available in 2011. In 2009 students had to save the workflow manually a few times a day. In 2011 this workflow saving was automated: any change to the workflow was instantly saved. In 2011 ExperD failed to provide feedback due to a technical problem.

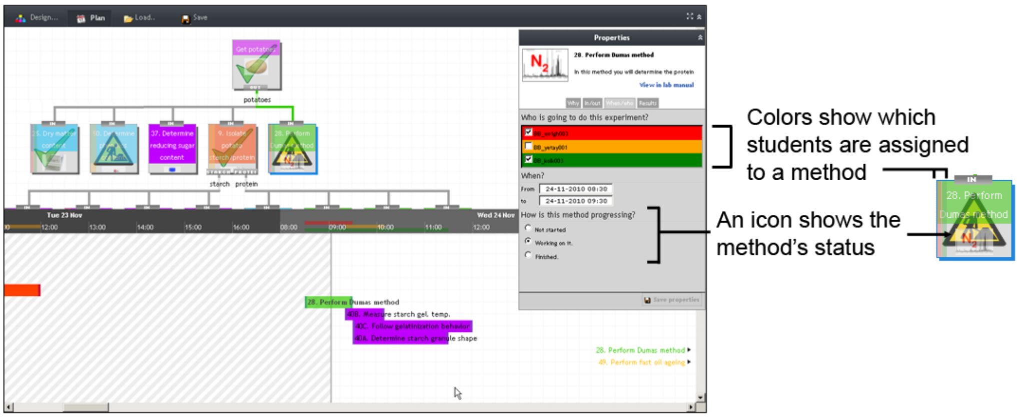
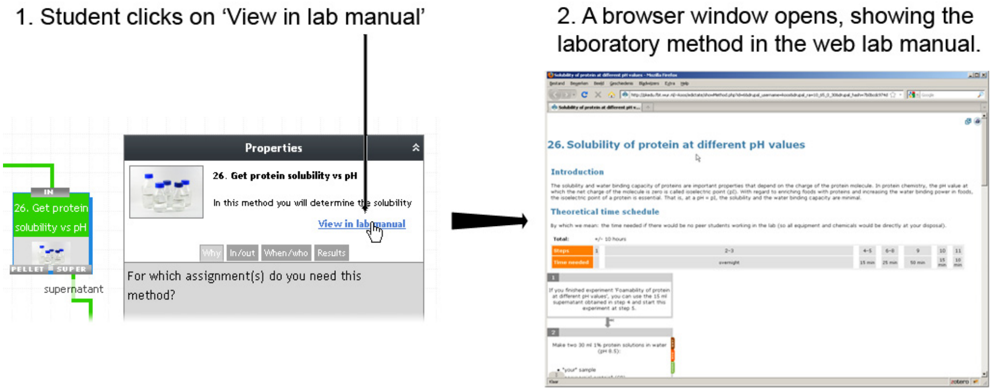


Figure 6: Overview of the time planning module with the ExperD (introduced in 2011). Each experiment is in the workflow represented by a horizontal bar in the time planning. The position and the length of this bar represent the starting time and the duration of the experiment. The shaded area in the time planner means the past, the white area the future. Each student in a group has a color (red, orange, green) and these colors are used throughout the user interface to show which method is assigned to which student(s). Icons are used to show the method's status: Whether it is 'in progress' or it has been 'finished'.



26. Get protein solubility vs pH

In this method you will determine the solubility

For which assignment(s) do you need this method?

Figure 7: ExperD is linked to a web based laboratory manual. Students can view the online manual of a particular method by clicking on the 'View in lab manual' link in the properties dialog.

In both editions of the course, students designed a concept workflow on the first day of the laboratory class. The teachers then gave oral feedback on the workflows, after which students made some adjustments. Students used the workflow throughout the remainder of the laboratory class, e.g. to see what experiments they scheduled for a particular day, to enter results, to update it, etc.

In 2009 (n=60) and in 2011 (n=98) the ExperD was evaluated by the students by means of a questionnaire, which they had to fill in after the laboratory class ended. In 2009, teachers of this laboratory class (excluding those who supervised the class for the first time, n=4) were interviewed by one of the authors a few weeks later. The 2011 teachers (n=6) were asked to comment on the conclusions of the 2009 interviews.

1.6 Collected Data

The results of the questionnaire are listed in Table 2. The most important outcomes from the teacher interviews from the 2009 case study were:

t1. The teachers find the ExperD a valuable addition to the laboratory class. It especially helped teachers in discussions with students during the laboratory class, because both they and the students could easily indicate certain points in a standardized workflow. All groups did forget to include one or more experiments in their initial workflow designs.

t2. Some teachers had indications that their students had more overview during the laboratory class than in previous years. For example: They recalled several occasions where students themselves found out that they could combine the samples for certain analyses. The teachers did not recall that this occurred in previous years.

t3. Some student groups seemed to have stopped thinking about the laboratory class design after they finished designing it. When asked ‘why are you doing this experiment?’, the answer these groups gave was: ‘Because it is in the scheme’.

t4. The ExperD allows groups to make a ‘perfect’ separation of tasks. ‘Perfect’ in the sense that students did not know what experiments other group members were doing. Within groups ‘specialists’ arose, who did all analyses of a specific kind, often without knowing anything about the samples they had to analyze.

These outcomes were confirmed by the 2011 teachers of the course.

In Figure 8 the percentage of groups updating and using the ExperD are plotted against time. The method status (whether a method was ‘in progress’ or ‘finished’) was kept up to date by 90% of all groups during the laboratory class.

In Figure 9 the ExperD usage and webLM usage are plotted per group. Between groups we found substantial differences in the intensity in which the ExperD was used (Figure 9), the most active group generating 11 times as much updates as the least active group.

1.7 Discussion

In the introduction we mentioned several challenges for our laboratory class, which were operationalized in a set of design requirements (Table 1). We will discuss whether these design requirements have been met, and come up with some recommendations to improve the ExperD.

1.7.1 Requirement 1 and 2: The ExperD should be Helpful for and used by Students

Students found it useful to make a design with the ExperD on beforehand (q1 in Table 2). Surprisingly, the 2009 students seem to find it more useful to design a scheme than the 2011 students. We have no explanation for this difference, but the design requirement r1 was met in both cases. A large majority (84-86%) of the students would like to see the ExperD to be available in other laboratory classes (q2). Students also indicate that the ExperD helped them to work efficiently (q5). Although this self-reporting has some value (e.g. with regard to student motivation), ‘working efficiently’ should be further operationalized in a follow-up study to make more objective claims. A similar conclusion can be drawn for ‘the ExperD gives students the overview’ (requirement 2c): We have indications that the ExperD gives students the overview (q7, t2), but also indications that point otherwise (t4). Although the students find the tool easy to use (q3, q8), the result for q4 “The ExperD is self-explanatory” is still unsatisfactory. This could be improved by offering students an interactive tutorial before they start designing, or by giving inline hints when they use the ExperD for the first time (e.g. a textbox near the main bar: ‘Click on a method to add it to the workflow’, followed by a textbox near the added method: ‘Click on a method to see its properties’, etc.).

Table 2: Questionnaire results of the 2009 (n=60) and 2011 (n=98) case studies. For each question two result rows are shown: the upper one being the results of 2009, the lower one the results of 2011.

#	Question	Answers (%) 1=disagree, 5=agree					% 4+5
		1	2	3	4	5	
q1	I found it useful to design a scheme.	0	3	0	30	67	97
		1	5	14	49	32	81
q2	I would like to have such an ExperD in other laboratory classes.	0	2	15	37	47	84
		0	2	12	48	38	86
q3	The ExperD was easy to use.	3	3	7	53	33	86
		0	7	11	59	22	81
q4	The ExperD is self-explanatory.	2	5	25	58	11	69
		0	8	15	67	10	77
q5	The ExperD helped our group to work efficiently.	0	3	3	58	36	94
		0	3	13	58	26	84
q6	The ExperD helped me to figure out what I could expect during the laboratory class.	2	2	10	64	22	86
		0	1	10	75	14	89
q7	The ExperD helped me to have the overview during the laboratory class.	0	0	9	64	28	92
		0	1	3	49	48	97
q8	It was easy to distribute tasks using the ExperD’s user interface.	3	3	19	41	34	75
		1	2	16	59	22	81

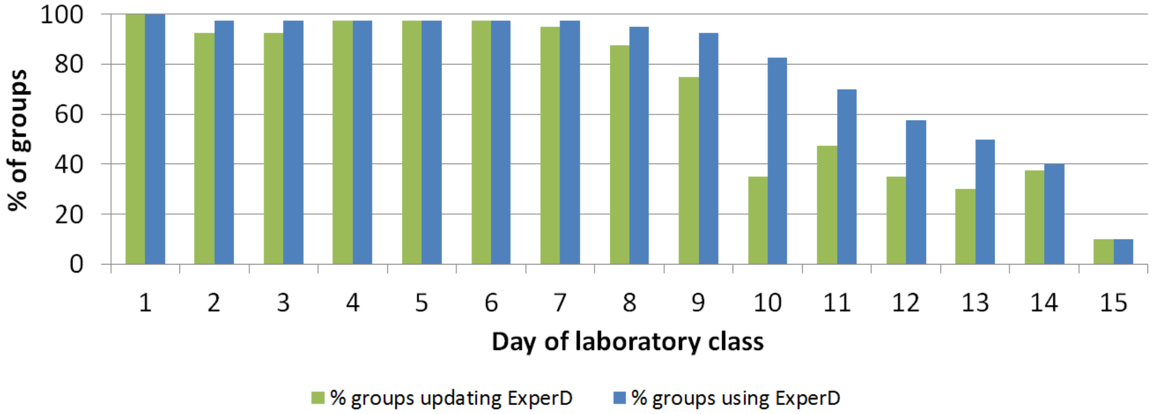


Figure 8: Percentage of groups updating and using their ExperD worklow at least once during the 2010 laboratory class. Groups making at least one change to their workflow are considered to be an 'updating' group for that day. Some groups did not update the workflow for one day, but did update it the next. Because we assume that these students did use the workflow in between (for viewing only), these groups are considered to be 'using' the ExperD on both days.

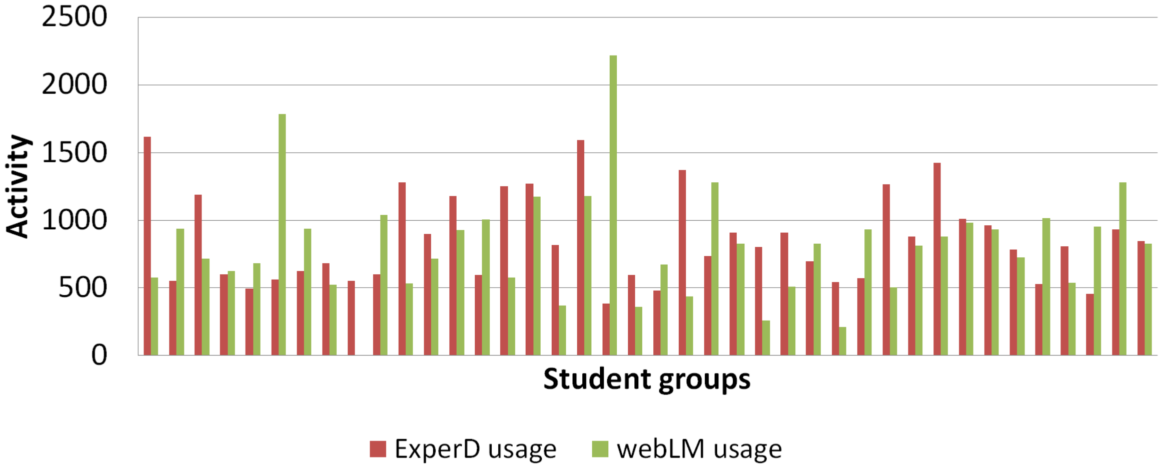


Figure 9: The ExperD and web lab manual (webLM) usages per 2011 group. To obtain the ExperD activity values, the number of laboratory methods changed in the workflow during the laboratory class was summed per group. The webLM usage was determined as described previously (Kolk et al. 2011). For one group, webLM usage data became unusable because of a problem in the logging software (the other groups were unaffected by this problem).

The majority (>80%) of the groups continued using their experimental workflow during the first 10 days of the laboratory class (Figure 8). The usage declines in the second and third weeks, most likely because laboratory class workflows did not need to be adjusted anymore and because groups finished their experiments. Earlier we expected that there would be 'computer minded' groups, which would use both the ExperD and webLM intensively, and less 'computer minded' groups, which would avoid using both tools. Our results indicate that this is not the case.

1.7.2 Requirement 3: The ExperD should be Appreciated by Teachers

In general, the teachers find ExperD a valuable addition to the laboratory class, as it helped them in their discussions with students (t1). However, teachers were somewhat unpleasantly surprised by the extent to which the ExperD enabled students within a group to work independently from each other (t5). It can be argued though, that ExperD made a 'weakness' of the laboratory class set-up apparent. Namely, that it is possible for a student group to solve the assignments and obtain a sufficient mark for the laboratory class without the student group members knowing what the others are doing.

Teachers observed that all student groups did forget to include one or more experiments (t2). Letting the ExperD check for 'childless' assignments (i.e. assignments without methods linked to them) or 'orphan' methods (i.e. methods in the workflow without assignments linked to them) could prevent these kind of mistakes in the workflows.

1.7.3 Requirement 4: The ExperD should Serve as a Monitoring Tool for Design Activities

Figure 8 and Figure 9 show possible usages of monitoring student design activities. Because each update to the workflows is saved instantly, teachers can monitor student design activities in real time from their own computer. This can help them e.g. in finding groups that are struggling to make progress during the laboratory class. Student groups have the possibility of changing the 'status' of an experiment in the workflow. For groups using this feature - 90% of all groups - a chart could be developed, in which group progress is plotted against time. This gives teachers a quick indication of how groups are performing in the laboratory class. Finally, the data generated by ExperD allows for replaying the workflow design process and reconstructing how groups progressed through the laboratory class. Analysing this process might be useful to find the problems students have with designing workflows of laboratory classes in general. It can also be used by teachers to detect difficult or unclear assignments and other bottlenecks in a specific laboratory class.

1.8 Concluding Remarks

The leading research question in this research was: Is it possible to design, realize and implement a web based experimental workflow design tool, which students find helpful, which teachers find valuable, which students really use and which can serve as a research/monitoring tool? In other words, we aimed to falsify the hypothesis that it is *not* possible to design, realize and implement such a tool. We believe that the case studies in which ExperD was used falsify this hypothesis and thus provide a proof of feasibility. ExperD is a highly-valued tool, used intensively by a large majority of the students within our laboratory class, and might be of use for both teachers and researchers. Since the 2009 evaluation, ExperD has also successfully been introduced to the laboratory classes of an interdisciplinary B.Sc. level course 'Food Related Allergies and Intolerances' and a M.Sc. level course 'Food Ingredient Functionalities'. We are currently in consultation with other chair groups at Wageningen University to investigate how to implement ExperD in their laboratory education.

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CrowdLearn: Crowd-sourcing the Creation of Highly-structured e-Learning Content

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Keywords: e-Learning, LMS, Crowdsourcing, (semi-)Structured Learning Objects, SCORM.

Abstract: While nowadays there is a plethora of Learning Content Management Systems, the collaborative, community-based creation of rich e-learning content is still not sufficiently well supported. Few attempts have been made to apply crowd-sourcing and wiki-approaches for the creation of e-learning content. However, the paradigm is *only* applied to unstructured, textual content and cannot be used in SCORM-compliant systems. To address this issue we developed the CrowdLearn concept to exploit the wisdom, creativity and productivity of the crowd for the creation of rich, deep-semantically structured e-learning content. The CrowdLearn concept combines the wiki style for collaborative content authoring with SCORM requirements for re-usability. Therefore, it enables splitting the learning material into Learning Objects (LOs) with an *adjustable* level of granularity. In order to realize the CrowdLearn concept, a novel data model called *WikiApp* is devised. The WikiApp data model is a refinement of the traditional entity-relationship data model with further emphasis on collaborative social activities and structured content authoring. We implement and evaluate the CrowdLearn approach with SlideWiki – an educational platform dealing with presentations and assessment tests. The article also comprises results of a usability evaluation with real students.

1 INTRODUCTION

While nowadays there is a plethora of Learning Content Management Systems (LCMS), the collaborative, community-based creation of rich e-learning content is still not sufficiently well supported. Few attempts have been made to apply crowd-sourcing and wiki-approaches for the creation of e-learning content. *Wikiversity*[1], for example, is a Wikimedia Foundation project aiming to leverage standard wiki technology for the creation of hypertext e-learning content. *Peer 2 Peer University (P2PU)*[2] and *PlanetMath*[3] are other examples which employ crowd-sourcing to create rich e-learning content. P2PU helps users to navigate the wealth of open education materials and supports the design and facilitation of courses. The PlanetMath is a project to aiming to become a central repository for mathematical knowledge on the web, with a pedagogical mission. However, we deem, that no real attempt has been made so far to truly apply the concepts behind wikis and crowd-sourcing to develop a specifically tailored technology supporting the creation of highly-structured, SCORM-compliant e-learning content.

Sharable Content Object Reference Model (SCORM) (sco, 2011a) as one of the community-approved standards, requires the transformation of the learning material into the sequence of annotated *Sharable Content Objects* (SCOs). The granularity and sequencing of the SCOs should be determined by the content author depending on the audience needs and preferences (sco, 2011b). Ward Cunningham's *wiki* (Leuf and Cunningham, 2001) paradigm is mainly *only* applied to unstructured, textual content. This limitation makes it difficult or even impossible to use the wiki style of content authoring in the SCORM-compliant learning platforms. As a result, a proper community collaboration, authoring, versioning, branching, reuse and re-purposing of (semi-)structured educational content similarly as we know it from the open-source software community is currently not supported. To address the issue we develop the CrowdLearn concept.

CrowdLearn exploits the wisdom, creativity and productivity of the crowd for the creation of rich,

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[1] http://wikiversity.org/

[2] http://p2pu.org/

[3] http://planetmath.org/

deep-semantically structured e-learning content. It combines the wiki style of collaborative content authoring with SCORM requirements for re-usability. Therefore, it enables splitting the learning material into *Learning Objects* (LOs) with an *adjustable* level of granularity. The CrowdLearn concept is based on five fundamental components (cf. 3): standard compliance, semantic structuring, enhanced possibilities for reuse and re-purpose, crowd-sourcing and social networking.

In order to implement and evaluate the CrowdLearn concept, we created a showcase application named *SlideWiki*. SlideWiki deals with the collaborative creation of original e-learning content such as presentations, slides, diagrams and self-assessment tests. During the implementation of the CrowdLearn concept, we faced several challenges (cf. 4). For enabling the high-level collaboration, all content should be versioned, similar to the wiki paradigm. SCORM has direct support for multiple-version content objects. However, we needed rules for triggering the creation of new revisions. Our findings on this issue are presented in 4.2. The next challenge was the SCORM requirement for the content to be structured. To solve this we developed the WikiApp data model (see 4.1) that organizes the relations between different content objects. Finally, the third challenge was to involve the learners in the process of content creation. We addressed this issue by providing support for social networking activities. Both content owners and students are able to participate in discussions about the learning material. While SCORM allows content engineers to do the sequencing, we allow it to be done by learners as well. As a consequence, semantically structured learning objects can be created and edited in a truly collaborative way. We further evaluated the CrowdLearn concept by conducting a comprehensive usability study with real students using SlideWiki (cf. 5).

2 RELATED WORK

Related work can be roughly divided into the following two categories:

Collaborative Creation of e-Learning Content. The importance of creating reusable and re-purposable e-learning objects is widely accepted by the e-learning community (Devedzic, 2006). However, most of the works address the learning object reuse problem rather by means of semantic meta-data annotations, content tagging and packaging than by creating richly structured, reusable learning objects from the ground. The importance of creating learning objects already with reuse in mind was, for example, stated by (Pedreira et al., 2009): *Content ... should be represented not as an object of study but rather as necessary elements towards a series of objectives that will be discovered in the course of various tests.* There are only few approaches for the direct authoring of reusable content, such as, for example, learning examples creation (Kuo et al., 2008) or semantic structuring and annotation of video fragments (Barriocanal et al., 2011).

We should also mention the *Learning Objects Repositories* (LORs), that allow to produce structured reusable content. The first of them, *Connexions* (http://cnx.org/), presents the learning material as a combination of paragraphs, each of them could be easily edited or deleted. However, this structuring is done more for comfortable editing and does not have any functional benefits: the paragraphs cannot be reused or annotated independently. Thus, Connexions presents just an improved user interface for wiki-based system. The second example of structuring, that is more close to our idea, is *LeMill*[4]. LeMill provides a way of collaborative editing of the presentations by implementing presentations as a group of images which can be edited collaboratively. However, to edit a slide, a user has to replace it with another one. Also, it is impossible to have several subgroups of the slides within a presentation. The search through the slides (not presentations) is also not implemented. Thus, slides cannot be manipulated as independent learning objects.

The CrowdLearn concept differs from the existing approaches for managing e-learning content. It enables the construction of *semantically structured learning objects* from existing sources by combining, reordering and simple editing. By the term *semantically structured object* we mean that all the parts within the structure own all the attributes and methods of the object type, or, in the case of learning content, are complete and fully-functional LOs.

Wiki-based Collaborative Knowledge Engineering. The importance of wikis for collaborative knowledge engineering is widely acknowledged. In (Richards, 2009), for example, a knowledge engineering approach which offers wiki-style collaboration, is introduced aiming to facilitate the capture of knowledge-in-action which spans both explicit and tacit knowledge types. The approach extends a combined rule and case-based knowledge acquisi-

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[4] http://lemill.net/

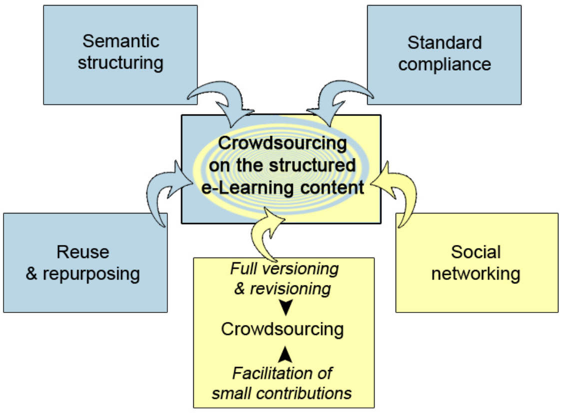

Figure 1: CrowdLearn concept.

tion technique known as *Multiple Classification Ripple Down Rules* to allow multiple users to collaboratively view, define and refine a knowledge base over time and space. In a more applied context, (Haake et al., 2005) introduces the concept of wiki templates that allow end-users to define the structure and appearance of a wiki page in order to facilitate the authoring of structured wiki pages. Similarly the hybrid wiki approach (Matthes et al., 2011) aims to solve the problem of using (semi-)structured data in wikis by means of page attributes. In our approach we apply the wiki paradigm to the creation and collaboration around (semi-)structured learning objects.

3 CrowdLearn CONCEPT

We see the CrowdLearn concept as an application of crowd-sourcing techniques to the e-learning content creation, re-purpose and reuse. As shown in 1, the concept is based on the following five strategies:

Standard-compliance. The costs associated with building high-quality e-learning content are high. One solution to decrease the costs is to author structured and reusable e-learning content that can be repurposed in different ways. To facilitate this, it should be possible to migrate content between different *Learning Management Systems* (LMSs). However, often content migration is not completely adequate and can thus result in loss of valuable content, meta-data or structure. Even if the transfer is possible, moving the content between systems can be more costly than just redeveloping that course in the new system. The strategy to overcome this challenge is the standard-compliance of both LMS and content. In that regard, we adopted the *SCORM standard* (sco, 2011a) and practical recommendations (sco, 2011b) and expanded the standard for the collaborative model.

Semantic Structuring. Instead of dealing with large learning objects (often whole presentations or tests), we decompose them into fine-grained *learning artifacts*. Thus, rather than a large presentation, user will be able to edit, discuss and reuse individual slides; instead of a whole test she/he will be able to work on the level of individual questions. This concept efficiently facilitates the reuse and re-purpose of the learning objects. To implement the concept, we employ the WikiApp approach, as discussed in 4.1.

Reuse and Re-purpose. The benefits of reuse and repurposing are: (1) increasing the cost efficiency of content creation, (2) increasing the quality of e-learning content and (3) supporting the evolution and adaptation to new requirements. To increase the economic efficiency of e-learning, content should be reused for a long period of time. Then, the development costs can be amortized over several years. However, the student expectations for higher quality e-learning experience increase, and new technology emerges so quickly that most courses need redeveloping every 3-4 year (Jones, 2002). Instead of the full redevelopment, the content can slightly evolve. In that case the courses remain competitive with regard to the provisioning of high quality e-learning content. The possibility to reuse and re-purpose is crucial for the e-learning content evolution. Also, re-purposing allows to increase the efficiency by teaching more learners with the same content.

Crowd-sourcing. There are already vast amounts of amateur and expert users which are collaborating and contributing on the Social Web. Harnessing the power of such crowds can significantly enhance and widen the distribution of e-learning content. Crowdsourcing as a distributed problem-solving and production model is defined to address this aspect of collective intelligence (Howe, 2006). CrowdLearn as its main innovation combines the crowd-sourcing techniques with the creation of highly-structured e-learning content. E-learning material when combined with crowd-sourcing and collaborative social approaches can help to cultivate innovation by collecting and expressing (contradicting) individual's ideas. As Paulo Freire wrote in his 1968 book *Pedagogy of the Oppressed*, 'Education must begin with the solution of the teacher-student contradiction, by reconciling the poles of the contradiction so that both are simultaneously teachers and students...'. Therefore, crowd-sourcing in the domain of educational material not only increases the amount of e-learning content but also improves the quality of the content.

Social Networking. The theoretical foundations for e-Learning 2.0 are drawn from *social constructivism* (Wang et al., 2012). It is assumed that students learn as they work together to understand their experiences and create meaning. In this view, teachers are knowers who craft a curriculum to support a self-directed, collaborative search and discussion for meanings. Supporting social networking activities in CrowdLearn enables students to proactively interact with each other to acquire knowledge. With the CrowdLearn concept we address the following social networking activities:

- Users can follow individual learning objects as well as other users activities to receive notification messages about their updates.
- Users can discuss the content of learning objects in a forum-like manner.
- Users can share the learning objects within their social network websites such as Facebook, Google Plus, LinkedIn, etc.
- Users can rate the available questions in terms of their difficulty.

Besides increasing of the learning process quality, social activities improve the quality of the created learning material. Even when answering a quiz, users can contribute by analysing the quality of the questions and making suggestions of how to improve them. Thus, the knowledge is being created not only explicitly by contributors, but also implicitly through discussions, answering the questions of assessment tests, or in other words through native learning activities.

4 CrowdLearn IMPLEMENTATION

We implement and evaluate the CrowdLearn concept with SlideWiki [5] – a web-based crowd-learning platform. SlideWiki deals with two types of (semi-)structured learning objects: slide presentations and assessment tests. SlideWiki follows our proposed *WikiApp data model* to facilitate the creation, repurpose and reuse of learning objects. In this section we first elaborate on the WikiApp data model and then discuss the technical implementation details of the SlideWiki application.

4.1 WikiApp Data Model

The WikiApp data model is a refinement of the traditional entity-relationship data model. It adds some additional formalisms in order to make users as well as ownership, part-of and based-on relationships first-class citizens of the data model. A set of content objects connected by *part-of* relations can be arranged and manipulated in exactly the same manner, as an individual non-structured object. The model natively supports versioning and structuring of the different content objects.

The WikiApp data model comes with a *Domain Specific Language* (DSL)[6] which allows the model-driven generation of CrowdLearn applications. We illustrate the WikiApp model in 2 and formally define it as follows:

Definition 1 (WikiApp data model)**.** *The WikiApp data model* $\mathcal{WA}$ *can be formally described by a triple* $\mathcal{M} = (U, T, O)$ *with:*

- U *- a set of* users.
- T *- a set of* content types *with associated property types* P_t *having this content type as their domain.*
- $O = \{O_{t \in T}\}$ *with* O_t *being* sets of content objects *for each content type* $t \in T$.

Each O_t *consists of content objects* $o_{t,i}$ *with* $i \in I_T$ *being a suitable* identifier *set for the content objects in* O_t*. Each* $o_{t,i}$ *comprises a set of properties* $P_{t,i} = Attr_{t,i} \cup Rel_{t,i}$*.* $Attr_{t,i}$ *is a set of literal, possibly typed* attributes*, and* $Rel_{t,i}$ *is a set of* relationships *with other content objects; The only necessary attribute for all content objects is* $c_{t,i}$*, which contains the creation timestamp of the object* $o_{t,i}$*.* $Rel_{t,i}$ *can particularly include the following designated relationships to related objects:*

- $part_{t,i} \subset O$ *refers to* set of the content objects *contained in* $o_{t,i}$ *;*
- $base_{t,i} \in O_t$ *refers to* base content object *from which the object* $o_{t,i}$ *was derived;*
- $user_{t,i} \in U$ *refers to a user being the* owner *of the* $o_{t,i}$*;*

The WikiApp model assumes that all content objects are versioned using the timestamp $c_{t,i}$ and the base content object relation $b_{t,i}$. In the spirit of the wiki paradigm, there is no deletion or updating of existing, versioned content objects. Instead new revisions of the content objects are created and linked to their base objects via the *base-content-object* relation. All operations have to be performed by a specific user and the newly created content objects will have

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[5] http://slidewiki.aksw.org

[6] More information available at: http://slidewiki.aksw.org/wikifier

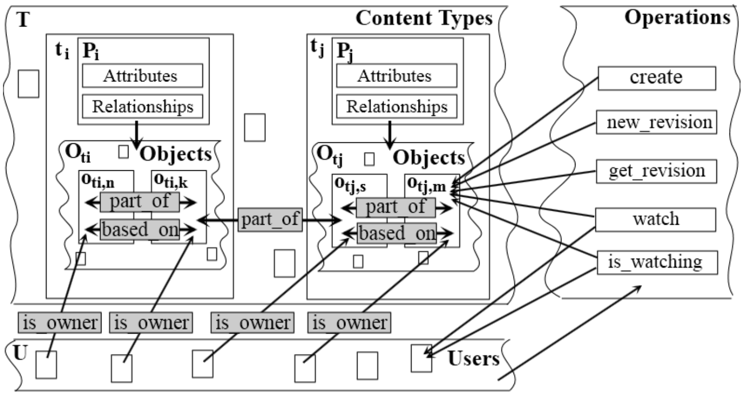

Figure 2: Conceptual view of the WikiApp data model.

this user being associated as their owner. In practice, however, usually only a subset of the content objects are required to be versioned. For auxiliary content (such as user profiles, preferences etc.) it is usually sufficient to omit a base content object relation. For reasons of simplicity of the presentation and space restrictions we have omitted a separate consideration of such content here. However, this is in fact just a special case of our general model, where the base content object relation $base_{t,i}$ is empty for a subset of the content objects.

The model is compatible with *both* the relational data model and the *Resource Description Framework* (RDF) data model (i.e. it is straightforward to map it to each one of these). When implemented as a relational data, content types correspond to tables and content objects to rows in these tables. Functional attributes and relationships as well as the *owner* and *base-content-object* relationships can be modeled as columns (the latter three representing foreign-key relationships) in these tables. The implementation of the WikiApp model in RDF is slightly more straightforward: content types resemble classes and content objects instances of these classes. Attributes and relationships can be attached to the classes via `rdfs:domain` and `rdfs:range` definitions and directly used as properties of the respective instances. For reasons of scalability we expect the WikiApp data model to be mainly used with relational backends. However, we also added a Linked Data interface using Triplify (Auer et al., 2009) (cf. 4.2).

Watching the users, as well as *following* the learning objects operations are natively supported by the model. This allows users to receive the information about changes of the followed content object or new objects created by the watched user. Also, these operations allow to easily find the followed object or user.

Our SlideWiki example application uses two implementations of WikiApp data model. The first implementation is used for managing slides and presentations. It includes individual slides (consisting mainly of HTML snippets, SVG images and metadata), decks (being ordered sequences of slides and sub-decks), themes (which are associated as default styles with decks and users) and media assets (which are used within slides). The second implementation was developed for managing questions and assessment tests. It includes questions for the slide material (the question is assigned to all slide revisions), tests (which could be organized manually by user or created automatically in accordance with the deck content), and answers (which are the part of the questions).

We implicitly connected these two WikiApp instances by adding two relations. Firstly, we assigned questions to slides. Thus, during the learning process users are able to answer the tests and have a look at the assigned slide if necessary. The important issue here is that we assign question not to individual slide revision, but for the slide itself. This decision gives an opportunity to create a new slide revision, that already has a list of questions, collected from other revisions. Secondly, we assigned assessment tests to concrete deck revisions. Thus the automatically created test saves the structure of the corresponding deck revision. This allows us to use module-based assessment to score the test results.

4.2 SlideWiki Implementation

The SlideWiki application makes extensive use of the model-view-controller (MVC) architecture pattern. The MVC architecture enables the decoupling of the user interface, program logic and database controllers and thus allows developers to maintain each of these components separately. The implementation comprises the main components: authoring, change management, import/export, linked data interface, e-

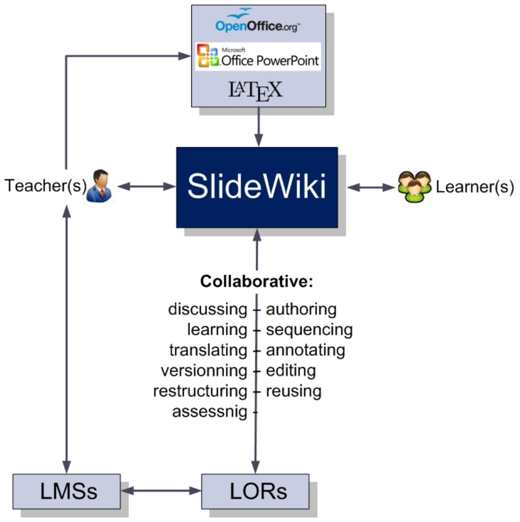

Figure 3: SlideWiki conceptual scheme.

assessment and translation. We briefly walk-through these components in the sequel.

Authoring. SlideWiki employs an inline HTML5 based WYSIWYG (What-You-See-Is-What-You-Get) text editor for authoring the presentation slides (cf. 5, image 1). Using this approach, users will see the slideshow output at the same time as they are authoring their slides. The editor is implemented based on ALOHA editor[7] extended with some additional features such as image manager, source manager, equation editor. The inline editor uses SVG images for drawing shapes on slide canvas. Editing SVG images is supported by SVG-edit[8] with some predefined shapes which are commonly used in presentations. For logical structuring of presentations, SlideWiki utilizes a tree structure in which users can append new or existing slides/decks and drag & drop items for positioning. When creating presentation decks, users can assign appropriate tags as well as footer text, default theme/transition, abstract and additional meta-data to the deck.

Change Management. Revision control is natively supported by WikiApp data model. We just define rules and restrictions to increase the performance. There are different circumstances in SlideWiki for which new slide or deck revisions have to be created. For decks, however, the situation is slightly more complicated, since we wanted to avoid an uncontrolled proliferation of deck revisions. This would, however, happen due to the fact, that every change of a slide would also trigger the creation of a new deck revision for all the decks the slide is a part of. Hence, we follow a more retentive strategy. We identified three situations which have to cause the creation of new revisions:

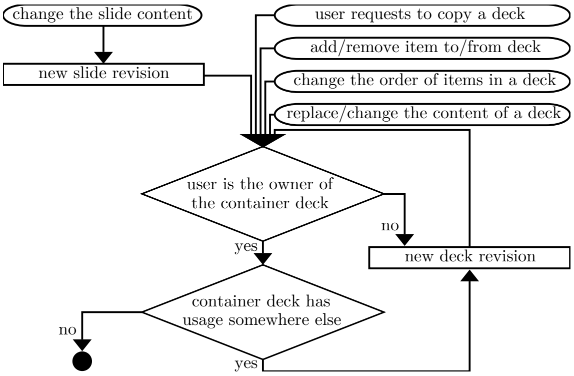

Figure 4: Decision flow during the creation of new slide and deck revisions.

- The user specifically requests to create a new deck revision.
- The content of a deck is modified (e.g. slide order is changed, change in slides content, adding or deleting slides to/from the deck, replacing a deck content with new content, etc.) by a user which is neither the owner of a deck nor a member of the deck's editor group.
- The content of a deck is modified by the owner of a deck but the deck is used somewhere else.

The decision flow is presented in 4. In addition, when creating a new deck revision, we always need to recursively spread the change into the parent decks and create new revisions for them if necessary.

Import/Export. SlideWiki implementation addresses *interoperability* as its first class citizen. As shown in 3, SlideWiki supports import/export of the content from/to existing desktop applications and LORs thereby allowing users from other LMSs to access the created content. The main data format used in SlideWiki is HTML. However, there are other popular presentation formats commonly used by desktop application users, such as PowerPoint .pptx presentations, LaTeX and others. We implemented import of the slides from .pptx format and work on the LaTeX format support is in progress.

Linked Data Interface. While sharing and reusing educational data across institutional and national boundaries is a general goal for both the public and the private education sector, the last decade has seen a large amount of research dedicated to Web-scale interoperability. For example, LinkedEducation.org is

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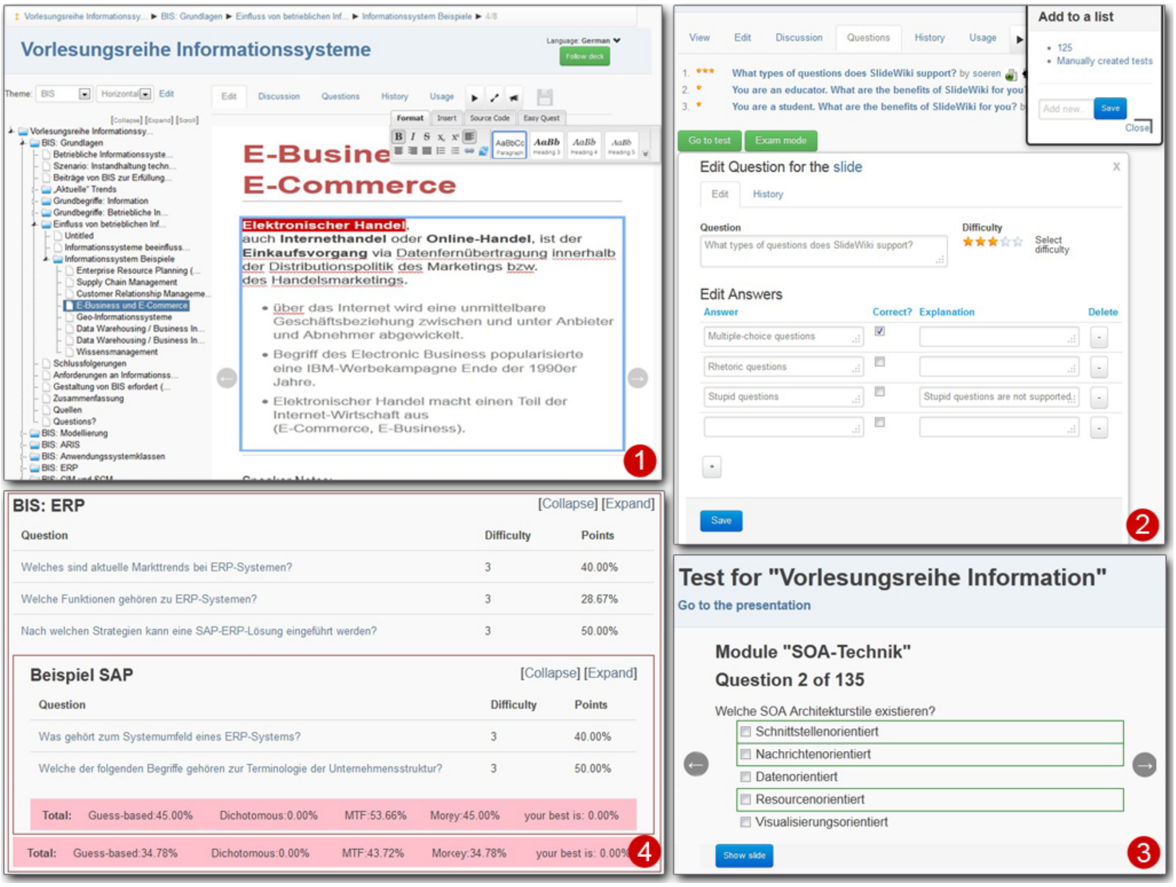
[7] http://aloha-editor.org/

[8] http://code.google.com/p/svg-edit/



E-Business und E-Commerce

Elektronischer Handel, auch **Internethandel** oder **Online-Handel**, ist der **Einkaufsvorgang** via Datenfernübertragung innerhalb der Distributionspolitik des Marketings bzw. des Handelsmarketings.

- über das Internet wird eine unmittelbare Geschäftsbeziehung zwischen und unter Anbieter und Abnehmer abgewickelt.
- Begriff des Electronic Business popularisierte eine IBM-Werbekampagne Ende der 1990er Jahre.
- Elektronischer Handel macht einen Teil der Internet-Wirtschaft aus (E-Commerce, E-Business).

1. ★★★ What types of questions does SlideWiki support? by soeren
2. ★ You are an educator. What are the benefits of SlideWiki for you
3. ★ You are a student. What are the benefits of SlideWiki for you?

Add to a list
- 125
- Manually created tests

Edit Question for the slide

Question: What types of questions does SlideWiki support?

Difficulty: ★★★☆☆ Select difficulty

Edit Answers

Answer	Correct?	Explanation	Delete
Multiple-choice questions	☑		-
Rhetoric questions	☐		-
Stupid questions	☐	Stupid questions are not supported.	-
	☐		-

Test for "Vorlesungsreihe Information"

Module "SOA-Technik"

Question 2 of 135

Welche SOA Architekturstile existieren?

☐ Schnittstellenorientiert
☐ Nachrichtenorientiert
☐ Datenorientiert
☐ Resourcenorientiert
☐ Visualisierungsorientiert

BIS: ERP [Collapse] [Expand]

Question	Difficulty	Points
Welches sind aktuelle Markttrends bei ERP-Systemen?	3	40.00%
Welche Funktionen gehören zu ERP-Systemen?	3	28.67%
Nach welchen Strategien kann eine SAP-ERP-Lösung eingeführt werden?	3	50.00%

Beispiel SAP [Collapse] [Expand]

Question	Difficulty	Points
Was gehört zum Systemumfeld eines ERP-Systems?	3	40.00%
Welche der folgenden Begriffe gehören zur Terminologie der Unternehmensstruktur?	3	50.00%

Total: Guess-based:45.00% Dichotomous:0.00% MTF:53.66% Morgy:45.00% your best is: 0.00%

Total: Guess-based:34.78% Dichotomous:0.00% MTF:43.72% Morgey:34.78% your best is: 0.00%

Figure 5: Four screenshots of SlideWiki features. ***1** - Tree structure of the presentation, inline WYSIWYG editor; **2** - Editing of a question and manual assigning to a test using lists; **3** - Question in learning mode with correct answers displayed; **4** - Module-based scoring of an assessment test.*

an open platform which promotes the use of Linked Data for educational purposes. In order to enable the export of SlideWiki content on Data Web as LORs, we employed the RDB2RDF mapping tool Triplify (Auer et al., 2009) to map SlideWiki content to RDF and publish the resulting data on the Data Web. The Triplify configuration for SlideWiki was created manually according to IEEE LOM standard and can be changed to support specific LORs. The SlideWiki Triplify Linked Data interface is available via: http://slidewiki.aksw.org/triplify.

e-Assessment. SlideWiki supports the creation of questions and self-assessment tests based on slide material. Each question has to be assigned to at least one slide. Important note here, that the question is assigned not to the slide revision, but to slide itself. Thus, when a new slide revision appears, it continues to include all the list of previously assigned questions. Questions can be combined into tests. The *automatically created* tests include the last question revisions from all the slides within the current deck revision. Manually created tests present a collection of chosen questions and currently cannot be manipulated as objects (cf. 5, image 2). Thus, in our implementation only questions and answers have to be placed under the version control. However, their structure is trivial and the logic of creating their new revisions is intuitive. We just restricted the number of new revisions to be created similarly with the decks: changes made by the question owner do not trigger a new revision creation.

For now, only multiple-choice (and multiple-mark) question type is implemented, however in the future we plan to expand the list of supported types. To score the results the student (or the teacher) can choose one of five implemented algorithms. Thus, dichotomous scoring gives points only when the answer was fully correct, other algorithms also count partially answered questions. Within other algorithms we implemented our balanced approach for scoring the multiple-mark questions, described in details in (**?**). All five algorithms use the dynamically accumulated difficulty *d* of the question as the number of points for the fully correct response:

$$d = \frac{incorr}{all} \tag{1}$$

If the user prefers to use dichotomous scoring, the values of *incorr* and *all* mean, respectively, the accumulated number of *incorrect* answers and *all* answers of that question by any of users. In a case of partial scoring, *incorr* is determined as follows:

$$incorr = \sum_{i=1}^{n}(1 - \frac{p_i}{d_i}), \tag{2}$$

where n - number of attempts for the question, d_i - difficulty (or maximal points), that the question had at the moment, when the ith attempt was made, p_i - points obtained in the ith attempt

After the difficulty is determined, it's scaled to $(1, d_{max}]$, where d_{max} is the maximal weight, that a question can have. d_{max} is set up by the system administrator only for the users' comfort. In SlideWiki we set it up to 5.

Students can start a chosen test (manually created or automatically collected) in one of two possible modes: "learning" or "examination". In learning mode student can ask to show the slide, to which the question is assigned to remind the material, or simply show the correct answers (cf. 5, image 3). Thus, student should not spend time to find the material. However, after the user asked to show her/him either the slide or correct answers she/he will not get any points for the question. In examination mode these features are disabled.

After choosing the mode the user can also set up the amount of questions (all, all the difficult or concrete amount) and the order to show them (random or increase the difficulty). As the amount of questions can differ for the same test, we show the test results as a percentage of the maximum points for exactly this selection of question.

Our architecture allowed us to implement module-based scoring. Each module of the assessment test presents a sub-deck of the presentation and is scored individually. Then, all the "parent" modules are scored as a sum of "children" points and finally the whole test is scored as a sum of all the points for all the modules (cf. 5, image 4).

Translation. Our architecture allowed us to implement a translation feature backed by the Google Translate service. After the translation into one of 54 supported languages, the presentation can be edited independently from the original one. However, we store the information about the original version and now we are working on the possibility to partially update the translated presentation when the original one was changed. Without such a possibility we faced with an important challenge. As we allow the owner of the revision to change it without creation of a new revision, it was an important issue: either we should allow the multiple translation of the same revision into the same language or not. For now we decided to allow it, however, this led us to the situation, that we would get several identical presentations with the content of bad quality, as it was translated automatically and was not edited manually. However, we could not disable the multiple translations, as in that case it would be for example impossible to get the translations of new slides, if they were added by the owner. Thus, the connection between original and translated presentations seems to be crucial. Also we think about supporting of the user and community thesauri.

5 EVALUATION

To evaluate the real-life usability of SlideWiki, we used it for accompanying an information systems lecture at Chemnitz Technical University. We structured the slides within the lecture series and added questions for student self-assessment before the final exam. We informed them about the different e-learning features of SlideWiki, in particular, how to prepare for the exam using SlideWiki. The experiment was not obligatory but students actively contributed by creating additional questions and fixing mistakes. The experiment was announced to 30 students of the second year and 28 of them registered at SlideWiki.

The students were working with SlideWiki for several weeks, and we collected the statistics for that period. During that period, they created 252 new slide revisions which some of them were totally new slides, others were improved versions of the original lecture slides. Originally the whole course had 130 questions, and students changed 13 of them, fixing the typos or adding additional distractors to multiple choice questions. In total, students performed 287 self-assessment tests. The majority of these used the automatically and randomly created tests covering the whole course material. 20 tests included only difficult questions, 2 asked to show the questions with increasing difficulty. This showed us that the students liked the diversity of test organization. Students also liked the possibility to limit the number of questions – 80 attempts were made with such a setting. 8 students reached the 100% result for the whole course. On average, it took them 6 attempts before they succeeded.

After the experiment we can claim, that more ac-

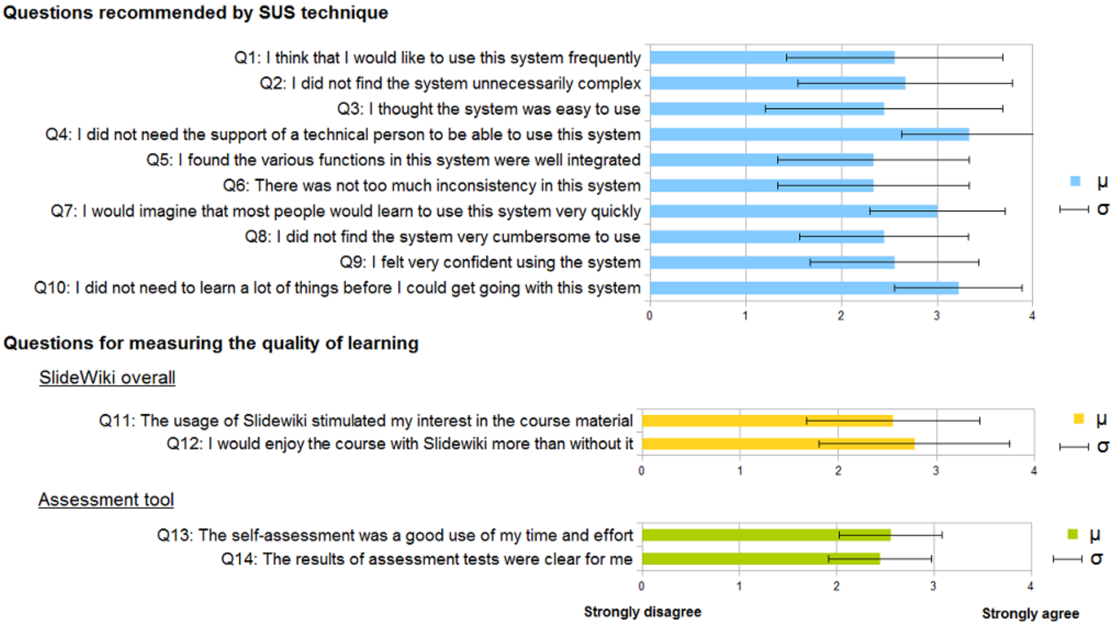


Figure 6: Results of SlideWiki evaluation survey: mean μ and standard deviation σ.

tive SlideWiki users received better marks on the real examination. It shows that SlideWiki not only allows students to prepare for the examinations, but also engages them in active participation that helps to improve the quality of the learning. After the end of the semester, we asked the participants to fill out a questionnaire which consisted of three parts: usability experience questions, learning quality questions and open questions for collecting the qualitative feedbacks. We collected 9 questionnaires that were filled out completely. They show us emergent problems and directions for the future.

In the first part of the questionnaire we included questions recommended by *System Usability Scale* (SUS) (Lewis and Sauro, 2009) system to grade the usability of SlideWiki. SUS is a standardized, simple, ten-item Likert scale-based questionnaire[9] giving a global view of subjective assessments of usability. It yields a single number in the range of 0 to 100 which represents a composite measure of the overall usability of the system. The results of our survey showed a mean usability score of `67.2` for SlideWiki which indicates a reasonable level of usability.

The second part of the questionnaire aimed to determine whether the SlideWiki helps to improve the quality of learning. It consisted of four questions with five options from “absolutely agree (1)” to “absolutely disagree (5)”. The evaluation results for these two parts are presented in 6.

Although the positive answers prevail, we were not satisfied by the fact that for many questions a third of participants chose the neutral value. It could be a signal, that students do not completely understand the question or are not 100% sure about the result.The last part of the questionnaire helped us to understand the reasons. We included four open questions:

1. What did you like most about Slidewiki?
2. What did you like least about Slidewiki?
3. What can we do to improve the Slidewiki’s usability?
4. What features would you add to Slidewiki?

Within the answers we found repeated complaints about several bugs, that interfered the working process. We consider this fact to be the main reason of neutral and contradictory values. However, we collected also positive opinions, especially about features and possibilities that SlideWiki allows. Three of the recipients mentioned that they mostly liked that SlideWiki is easy to use, four of them noted, that they liked the idea of collaborative work and sharing the presentations itself. Within the collected answers we also got important suggestions, which could be roughly divided into two groups:

- Suggestions about desired improvements of existing features such as displaying the test results graphically, supporting more import formats, improving the SVG editor etc.
- Suggestions about totally new features, several of those were later implemented, e.g. translation, templates for presentation structure, etc.

Also we collected a few suggestions about features

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[9] www.usabilitynet.org/trump/documents/Suschapt.doc

that were already implemented, but users were not aware of them. This encourages us to improve the documentation as well as to enhance the simplicity and clearness of the user interface. One of the students drew our attention to security issues.

The results of our evaluation showed that our concept is clear to the users, they like this way of learning, storing and sharing of the presentations. However, we need to improve the user interface, fix some minor bugs and spend more effort on privacy and security issues.

6 CONCLUSIONS AND FUTURE WORK

In this paper we presented the CrowdLearn concept that applies collaborative authoring and crowdsourcing techniques to the creation of (semi-) structured e-learning content. The concept is based on the SCORM concepts and uses the novel WikiApp data model to organize the content closely aligned with the standard. We implemented and evaluated the concept with SlideWiki – a social web e-learning application targeting slide presentations and e-assessments. While the evaluation results were promising, we still need to extend the concept in the future to address the requirements requested by users.

Beside the usability improvements, our first direction for future work is to implement a completely SCORM-compliant LMS and authoring tool, based on the SlideWiki. This will allow us to exchange the content with other SCORM-compliant LMSs. Also, in a real e-learning scenario, learners come from different environments, have different ages and educational backgrounds. These heterogeneities in user profiles are crucial to be addressed when enhancing the CrowdLearn concept. New approaches should provide the possibility to *personalize* the learning process. Thus, our second direction is providing the personalized content based on initial user assessments. The third direction for the future work is to support the annotation of learning objects using standard metadata schemes. We aim to implement the *LRMI*[10] metadata schemes to facilitate end-user search and discovery of educational resources.

ACKNOWLEDGEMENTS

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[10] Learning Resource Metadata Initiative: www.lrmi.net/

Development of an Analysis System and Class Recordings linked to More than One Course Evaluation Data using Smartphones

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Abstract: In this present research, we have developed a class analysis system with the goal of lesson improvement. The system is web-based application, and works by general hardware, for example standard laptop, USB cameras, and smartphones. The characteristics of this system are, while recording the lesson with two USB cameras, more than one classroom observer can record lessons using three buttons (“good!”, “what?”, “!?”) and one text field with the smartphone as an information evaluation input terminal. Using this lesson analysis system, you can reduce the specialized equipment that is needed when recording and analysis of the class. So, when the teacher is reflecting back on his own class and making refinements to the lessons, they can do it quickly and easily. In this study, at an actual elementary school in Japan, for the teacher to reflect upon their lessons, it will be beneficial in actually using this system to make improvements to the class.

1 INTRODUCTION

"Lesson Research" has long been conducted in Japan. In lesson research in Japan, after the class is over, it's common for the teachers who conduct classes, and the person who sits in on the lesson (for inspection) to have an open meeting reflecting back about the lesson that took place. In the meeting, the participants will have a discussion about the good points and bad points of the lesson. Through this review, the teacher is able to refine the technology for conducting lessons in a class. The technique of using audio-visual equipment for the analysis of classroom lessons came into the field of educational technology in the 1970s. Since that time, methods to record lessons using a video camera and for reflecting on those lessons using video have been developed. This method that had been used of the teacher and class inspector reflecting on the lesson after class using recorded video was called “class analysis by stop motion method”. In particular, "VTR interruption strategy" several video cameras are prepared, recording teachers and students at the same time, then at the class review meeting that video footage is paused for discussion. With a method of using recorded video lessons like this, many can share the video scenes more concretely. So, rather than a meeting about the lesson that relies solely on memory, it can be discussed based on the images that can be commonly understood by everyone which is an advantage. However, looking at the video from the beginning to the end of class requires more time, or about the same as the class time. And, even if you want to see only the class scenes of concern, it is difficult even to fast-forward to the scene in the video. When recording with a single camera, you can only record from one point of view. In the introspection meeting, it’s important to grasp not only what the teacher is doing, but also what the students are doing as well.

For that reason, it certainly is better if multiple video cameras were installed in the classroom. But eventually, because the preparation is an enormous task, there is no opportunity to use this setup on a daily basis. It is in these recent years by a dedicated data input terminal that marking above the recorded video’s timeline to cue distinguishing scenes and a system that can also look back on the each lessons evaluation information has been developed (Photron, 2012). This is available for a wide range of training, such as teaching nursing practice and job interviews. However, although the function is good however because of the high price it is not easily available in the general education setting. Furthermore, in addition to the evaluation information input terminal and special equipment, you must purchase the required number of devices.

In this study, we aimed to develop a class analysis system that can use ordinary smartphones as evaluation information input terminals

2 SYSTEM OVERVIEW

2.1 Development Concept

The concept of this development system is to reduce the burden on the user as much as possible without the use of a special environment or equipment. Therefore, a Centrino spec Windows laptop with a Core2 CPU, and 1 GB of memory, can run iPhone and Android smartphones or phones as a cheap ordinary USB camera, and evaluation of information input device. The operating environment was composed of all freeware. As a development idea, we expect to formulate a "good!" lesson and to promote the improvement of teaching classes. So we named this system Good Processor.

2.2 Structure of the System

The system configuration can be broadly divided into the following components:

1. Web server
2. Recording process
3. Screen drawing
4. Evaluation input process
5. Composed of the data storage unit

As mentioned previously, the system is configured with all freeware. The Web server is using Apache, the recording process is managed using Red5; the data storage is handled by PHP and MySQL, and Flex is used for graph drawing and operation screen (Figure 1). Once installed, it's not necessary to adjust the settings for everything in order to start the OS service level. When you want to use the system, if you connect a USB camera to a PC it's possible to start taking recordings of the lessons.

By way of a Wi-Fi connection, possibly a 3G, evaluation data is sent to the system from the smartphone or mobile phone in use by the inspector. Since the system provides no constraints with regard to the number of connections, it's possible to make connections up to the limit of the physical Wi-Fi

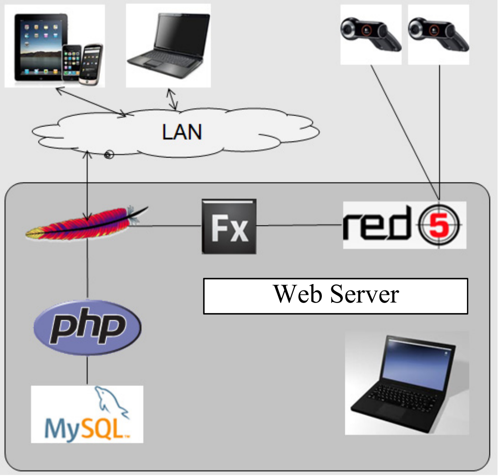

Figure 1: Structure of the System.

2.3 System Functionality

The system consists of a component that displays the analysis result from the recorded data and a part that records the lesson data. In order to record data, the person inspecting the class holds a smartphone or tablet PC and an evaluation input page for instructional use is display (Figure 2).

Figure 2: An evaluation input page on a smartphone.

The evaluation input page, has 3 kinds of buttons, and a comments field. The inspector while observing the lesson presses the "good!" button when they think it's good and presses the "what?" button when they think it's not so good, and after it's confirmed the "!?" is pressed when they think it's good. If, when you want to record something of note, you can also send comments. While receiving evaluation data from each terminal, the systems records what kind of evaluation data was sent, when, and from which terminal into a database. When the class concludes, the analysis results screen appears (Figure 3).

Figure 3: A sample of an analysis results screen.

At the analysis screen, evaluation information that was recorded is added up, and a comment and graph display is performed. By the data display, there is a recorded video lesson and comments, a chart that can add up each data at any time interval and, one can grasp the state of the class by the time series line chart graph that's connected with that. When each data is clicked, the video is cued to the scene that was sent to that data. The evaluation information time that was sent is recorded in seconds in order to make a graph seek the aggregate results minute by minute by the initial settings. This time, the options are modifiable depending on the purpose. For example, if a graph is made for the aggregate results every 10 minutes, one is able to grasp the rough state of the class. On the other hand, if we aggregate every 30 seconds one will understand the lesson in finer detail. By clicking on the video, graph or comment the display can be enlarged. By using this, one can see easier when reflecting on class lessons (Figure 4).

3 CLASS ANALYSIS CASE

Good Processor has been adopted as a means to improve the teacher's lecture in Miyagi Prefecture Iwanuma city school. In this paper, a case that took place on 9/28/2012 is described. The class was a second grade Japanese language class. In this class, "watch for scenes in the story, and being able to read the feeling and state of a person" are the goals. There were 22 teachers who sat in on classes and entered the evaluation information. Evaluators, with smartphone in hand, visited classes while taking notes with a pen, as shown in figure 5.

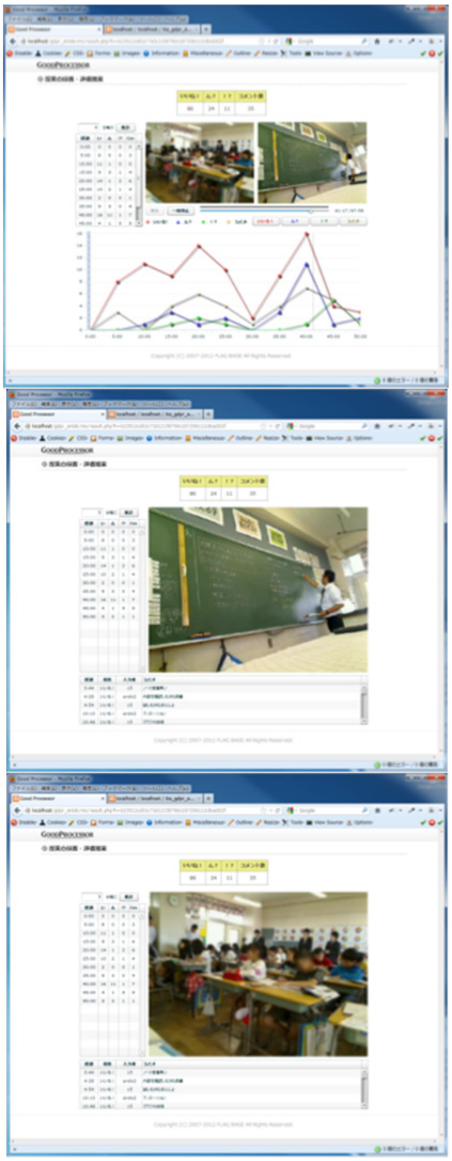

Figure 4: Views of enlarged each element.

Figure 5: An evaluator, with smartphone in hand, inputting comments and remarks while taking notes with a pen.

Figure 6 shows the state of class in an actual situation. In the foreground, a notebook that has the system installed is pictured.

Figure 6: A state of class in an actual situation.

After the lesson, all the teachers who sat in on classes had a meeting reflecting on the lessons at the Board of Education. At this conference a description was given about the classes that day from the teachers that made the first lessons.

Next, the teachers who participated were divided into groups and discussed good points, improvements and the points that have been devised based on the results of the analysis about the lessons. And then we present the results that were discussed, and a concrete improvement plan was discussed with all the participants. Finally, we received advice from the Board of Education committee.

Figure 7 is a line chart shown in a time series of the lesson evaluation data.

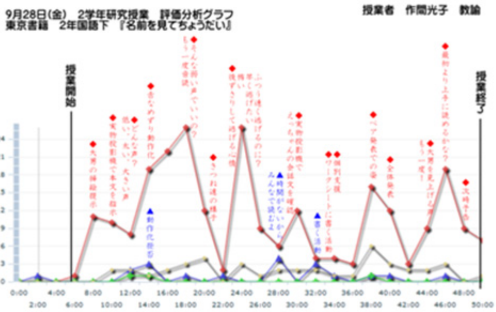

Figure 7: Time series line graph.

This diagram has the aggregation set for every 2 minutes. The line has changed considerably; however "good!" shows changes that were pressed. Although we see there are some mountainous peeks, those parts mean the places many people thought were " good " scenes. Near the bottom of the diagram, another graph can be seen. "what?" button is the state of how little has changed can be seen at the bottom of the figure.

In this class, around 20 minutes after the start of the lesson, there is a scene in which the inspectors received a "not so good" impression. We know that there was something wrong with that part of the lesson, since the graph of "good!" has fallen. On the other hand, around 38 minutes after the start of the lesson, despite the increasing number of "good!" we have found many people who received the "not so good" impression.

In summary, since the evaluation is divided, this scene can be said to be a scene that is worth discussing concerning what someone would think. In the class, there are times where the best scenes that were evaluated where in the middle of the first half of the class. Here, some scenes the teacher questioned the students regarding reading. These scenes are an important influence that greatly affects the success or failure of this class. These scenes, which are the top rated, can be said to have the desired results. On the other hand, after 28 minutes, the number of "good!" reduces and "what?" increases. This part is, is the place many people in the class thought "what?" since we have less time than the rest of the lesson plan, this part is a scene in which the teacher has changed the schedule of classes. Before this scene, the students were talking about when reading, how to tell a story vividly to the listener. However we were not able to take advantage of the results of that discussion.

In the case of the debate by the inspectors, when using the system it was easy to understand if it were a scene where you needed to hold discussions. But if this system is not used, the inspectors would just say the point that they were worried about and would have spoken only what they thought. However, using the system, the differences of opinion and other people's thoughts appear in the shape of a graph. When using a survey by questionnaire available in a 5-point scale, the readability of the screen had an average rating of 4.4, and the readability of the results was 3.9. The main comments of "it's interesting and could be evaluated quantitatively in class", "other teachers could understand how their feelings changed while observing the class", and "they could grasp the most critical point of the lessons" was the positive assessment of the class. On the other hand as for improvement points, "because I'm not accustomed to the operation of a smartphone I wouldn't know how to use it", "the weight of the smartphone is a bit heavy", "I want to also see the analysis result screen on a tablet PC" were some of the things mentioned.

4 CONCLUSIONS

In this study, a system for analysis and reflection of class lessons was developed. The goal was to make it easy as possible in a practical classroom and for an investigative review committee to examine. The system can record lesson from two point of view and evaluation data from more than one classroom observer inputted by smartphone. By using a smartphone made to correspond to the input terminal, the preparation was possible in a short time even when using a laptop and USB camera. From the graph and chart that aggregates the data, the flexible visualization of the class could be realized.

At an actual elementary school, it was used as a means to look back on the lessons and I was able to get high ratings from teachers. And, the main comments from teacher were the positive assessment of the class. However, there were several comments as for improvement points of the system. For that reason, In the future, it is necessary to proceed with the support in the form of a tablet PC and other devices.

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Towards Linked Data in Physics

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Keywords: Semantic Web, Linked Data, Linked Science.

Abstract: Linked Data refers to machine-understandable data published on the Web using the Resource Description Framework (RDF). Publishing and linking data using RDF make data easier to discover and easier to use. Nowadays, Linked Data principles have gained popularity in many fields. In this paper we are going to examine the possibility of obtaining Linked Data in physics. In particular, we discuss the principles of Linked Data in the context of publications on physics and present examples of Linked Data in a branch of physics called quantum mechanics. Moreover we present a web tool supporting manual creation of Linked Data in domains in which automating extraction of the data is not possible.

1 INTRODUCTION

Linked Data refers to machine-understandable data published on the Web using the Resource Description Framework (RDF). The key feature of RDF is that it allows us to link identifiers for entities (e.g. digital objects, real objects, abstract concepts) and not just documents (as HTML). Moreover, RDF links are typed, i.e. the nature of connection between two linked entities can be stated explicitly. Publishing and linking data using RDF will make data on the Web easier to discover, more accessible and, thus, easier to use. Until now, Linked Data principles have gained popularity in many fields and are applied to various kinds of data, e.g. government data (Sheridan and Tennison, 2010), commerce (Hepp, 2008), education and social media (Heath and Bizer, 2011). Applications of Linked Data can be also found in various branches of science, e.g. in geography (Sren Auer and Hellmann, 2009), biomedicine (Ciccarese et al., 2008), chemistry and biology (Wiljes and Cimiano, 2012). The Linked Open Data initiative of the University of Münster (LODUM)[1], which aims to publish any non-sensitive data online according to the Linked Data principles is worth mentioning (Kauppinen et al., 2013).

The purpose of this study is to examine the possibility of obtaining Linked Data in physics. Generally, the data and knowledge are usually contained in research articles and books. They usually involve considerations using advanced mathematical formalism. The data may also be formed into plots and tables (e.g. data from experiments). These ways of storing scientific data implies difficulties in data processing, in particular searching for information. The searching is usually restricted to full text search. Machines are not able to integrate data from the articles. From a machine point of view the articles are data islands. And widely used citations are nothing more than relations between articles. As a consequence a statement that article A cites article B has no precise meaning. Does it mean that in article A the ideas and propositions from article B are creatively developed? Or does it mean that in article A article B is only merely mentioned? To answer these questions we have to look through the article. The question arises then whether it is possible to represent data and knowledge available in physics in such a way that will enable integration, reusing and sharing the data i.e. according to Linked Data principles. In order to answer this question, we focus our attention on a branch of physics called quantum mechanics. The main reason for this choice is central importance of the theory for other branches of physics and technology. Moreover, in order to obtain Linked Data, we need formal representations of domain-specific terms which can be used in RDF descriptions. In the case of quantum mechanics we are developing an ontology which is suitable for this purpose (Skulimowski, 2010).

In the rest of paper, we analyze the principles of Linked Data in the context of data and knowledge available in quantum mechanics. In particular, we give an example of Linked Data for this disci-

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[1] http://lodum.de

pline. We also present a draft version of a web tool shortly called LYR (Link Your Research) which supports manual creation of Linked Data in domains in which automated extraction of the data is not possible (e.g. quantum mechanics). The paper ends with a short discussion and an outline of future work.

2 RELATED WORK

Previous work related to the presented research have already been done. Several approaches for a creation of linked data have been proposed. Among them there are automated approaches and approaches supporting manual creation (Wiljes and Cimiano, 2012). In order to describe data appropriate vocabularies are needed. As a result various ontologies have been developed, e.g. supporting semantic publishing and referencing (SPAR)[2], scientific discourse[3] and open annotations in science[4]. There also exists a number of systems similar (in some sense) to LYR. ScienceWISE Platform allows a community of scientists annotating and bookmarking research articles using appropriate ontologies (Aberer et al., 2011). Annotations can be also created using 4A framework based on idea ”annotations any where, annotations any time” (Smrz and Dytrych, 2011). Scientific workflows and other artefacts can be published, shared and discovered using ^{my}Experiment Virtual Research Environment (Goble and Roure, 2007).

3 LINKED DATA PRINCIPLES AND QUANTUM MECHANICS

Tim Berners-Lee introduced Linked Data principles describing a set of best practices for publishing structured data on the Web (Berners-Lee, 2006). Let us now consider the principles in the context of data and knowledge contained in research publications on quantum mechanics.

3.1 Naming Things with URI

The first Linked Data principle advocates naming entities (real or abstract) with URIs (Heath and Bizer, 2011). However a question may arise, whether it is possible for entities appearing in research articles on quantum mechanics. In this case the entities usually correspond to some ’elements’ of mathematical structure of the theory e.g. *observable, quantum state, orthogonality*. There are also entities corresponding to the structure of an article e.g. *definition, theorem, lemma*. In order to name these entities with a URI we can utilize the Web accessibility of the research article through the URL. And this URL can be used to obtain URIs for the entities considered in the article. Let us then consider a research article with the following URI:

`http://example.org/art3`

We want to assign URIs to various entities from the article. Assume, for example, that some *Concept* is considered in the article. Then it is possible to name this concept with the URI:

`http://example.org/art3#Concept`

It happens sometimes that an element considered in an article (e.g. *equation, condition*) has no special name. Inside of the article we can refer to it using its number (e.g. *...equation (12)..., ...condition (7)...*). This number can be also used to assign a URI to the element e.g.

`http://example.org/art3#12`

Standard elements of an article corresponding to its structure (e.g. *theorems, definitions, lemmas* etc.) are usually numbered too. These numbers can be also used in naming the elements with URIs e.g.

```
http://example.org/art3#Theorem_3
http://example.org/art3#Definition_2
```

In addition, elements of the theory considered in articles are very often denoted by symbols e.g. ψ, H_2. In these cases it is possible to assign a URI using (simplified) Latex symbols e.g.

```
http://example.org/art3#Psi
http://example.org/art3#H_2
```

for ψ and H_2.

As the above examples show that it is possible to name various entities from research publications with URIs. Notice, however, that in the case when one entity is named with two different URIs (e.g. using an entity name and an entity number), URI aliases will appear.

3.2 Providing Useful RDF Information

Descriptions of resources that are intended for machines should be represented in RDF. In general, it is an impossible task to represent the whole scientific article on quantum mechanics using RDF triples. This is mainly because of the complicated mathematical

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[2] http://purl.org/spar/

[3] http://purl.org/swan/1.2/discourse-relationships/

[4] http://www.purl.org/ao/

formalism used in the theory which obviously cannot be represented in RDF. We may, however, apply a light-weight approach and concentrate only on RDF links between elements of the theory considered in some article and elements of the theory from other articles or publications. Moreover, one may try to determine types of the elements assigning them to vocabulary terms (see Fig.1).

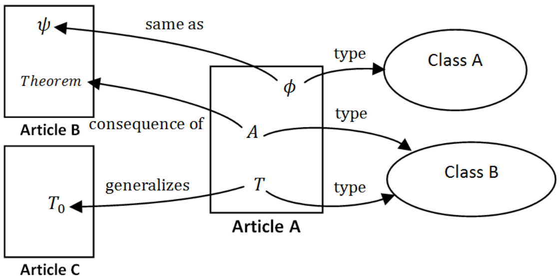

Figure 1: RDF links between entities from article A and entities from articles B and C. The entities from article A are also linked to classes from ontologies.

In order to create RDF links in quantum mechanics we need an appropriate vocabularies. The vocabularies are formally defined in the following ontologies:

- quONTOm[5] - an OWL ontology describing main concepts (e.g. *observable*, *Hamiltonian*, *spin*) and relations (e.g. *commutator*, *orthogonality*) in quantum mechanics. Aside from quantum mechanical concepts and relations, the ontology contains elements which in fact do not belong to the domain of quantum mechanics e.g. mathematical objects which should be contained in an ontology for mathematics. Unfortunately, to our best knowledge, an appropriate ontology for mathematics, which could be imported and used in quONTOm ontology does not exist. However, we think that in the future these concepts will be separated from the ontology and become parts of auxiliary ontology (or ontologies).
- PHYSO (Physical Sciences Ontology)[6] - an ontology describing general concepts (e.g. *principle, problem, assumption*) and relations (e.g. *has property, consequence of*) of physical sciences. The ontology can be used to characterize component parts and relations of any physical theory and not only quantum mechanics.
- SACO (Scientific Article Content Ontology)[7] - an ontology containing a set of objects properties enabling description of what is done/used in a research paper. In such article something (e.g. some element of the theory) is *analyzed*, *described* etc. Equivalently, using 'dummy' subject, we can say that the paper *considers*, *describes* something (Glasman-Deal, 2010).

We stress that above ontologies are at the moment incomplete and are gradually developed towards more complete forms. Consequently, parts of them might be changed in the near future.

3.3 Including Links to Other Things

The fourth principle of Linked Data recommends including links to other URIs. These links are crucial because they enable the discovery of additional data resources. There are three types of RDF links.

Relationship Links. In one research article an entity (e.g. *equation, concept, definition*) from another article can be used (e.g. generalized). Assuming that this element is named with a URI (according to one of the methods considered above) we can create the following RDF link pointing to this element:

```
art3:H phys:generalizes art6:H_0 .
```

A reference to some concept introduced in another article can be represented by the following link:

```
art3:Concept sac:isIntroducedIn
<http://ex2.org/art6> .
```

where `http://ex2.org/ar6` is a URI of the article. Moreover, it is very often that some entity introduced in one article is a solution to a problem considered in another article. We can express this by the following relationship link:

```
art3:10 phys:solutionTo art6:Theorem_5 .
```

Identity Links. An important part of RDF links in Linked Data are identity links. An element of the theory (e.g. *operator, concept, definition*) may be named with two different symbols in two different articles. In this case we can create the following identity link:

```
art3:V_1 owl:sameAs art6:W_1 .
```

It may happen that the same definition may have two different numbers in different articles. We can represent the situation as follows:

```
art3:Def_1 owl:sameAs art6:Def_2 .
```

Identity links are very important because they enable expression of different views on the same element of the theory named with URI. Moreover, they enable clients to retrieve further descriptions about the element.

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[5] http://purl.org/quONTOm

[6] http://purl.org/lyr/physo

[7] http://purl.org/lyr/saco

Vocabulary Links. The last type of RDF links are vocabulary links pointing to definitions of vocabulary terms. For example, in a research paper on quantum mechanics some observable C_2 can be considered. Then we can create the following link:

`art3:C_2 rdf:type quo:Observable.`

It is shown in the next section that RDF links can be used in RDF descriptions of research articles.

4 LINKING RESEARCH DATA

Let us assume now that we want to create RDF links for some research paper on quantum mechanics. This can be done in the following steps:

1. We choose entities from the article which we want to describe in RDF (e.g. *concept 7, formula (12),* Ψ_n etc.).
2. We name the entities with URIs (different ways of creating URIs were presented in the previous section).
3. Next we determine the relation between the paper and the chosen elements (using e.g. SACO ontology).
4. Using appropriate ontologies (e.g. PHYSO, quONTOm), we determine types of chosen elements. In this way we create *vocabulary links*.
5. We add *identity links* pointing at URIs used in other articles to identify the same entities.
6. We create *relationship links* between the entities of the considered article and entities from other articles.

We assume that RDF links obtained initially may be incomplete. The quality and depth of detail can be improved over time by adding new RDF links by the research community. There are many reasons for this 'progressive enrichment' (Dodds and Davis, 2011). For example, the creator of the initial RDF links could not know about some facts. Another reason may be some change or improvement in the vocabulary that was used. It very often happens that results of a paper are used in some other paper published later in the future. Then appropriate RDF links between the two papers should be added.

4.1 Example

Let us now consider an example of Linked Data for the case of quantum mechanics. To this end we take into account a research paper available online at arXiv[8] with the following URL: http://http://arxiv.org/abs/1101.3969v1. The paper is related to so called time operator problem. For convenience, we will use the following prefixes: `sac` - Scientific Article Content Ontology, `quo` - quONTOm Ontology, `dr` - SWAN Discourse relationships vocabulary.

In order to obtain RDF links we follow steps presented above:

1. We want to describe in RDF the following entities from the article: M, $\mathbf{g}_{m,\lambda}$, $\sigma(M)$.
2. URIs assigned to the entities: `<#M>`, `<#g_(m,lambda)>`, `<#sigma(M)>`.
3. Relations between the article and the entities:

```
<> sac:analyzes <#M> .
<> sac:determines <#g_(m,lambda)> .
<> sac:determines <#sigma(M)> .
```

4. Types of the entities:

```
<#M> rdf:type
quo:SelfAdjointOperator .
<#g_(m,lambda)> rdf:type
quo:EigenStates .
<#sigma(M)> rdf:type
quo:OperatorSpectrumBounded .
```

5. Identity link:

```
<#M> owl:sameAs
<http://link.aip.org/link/
doi/10.1063/1.3276419#M_F>
```

6. Relationship links:

```
<#M> quo:hasEigenStates
<#g_(m,lambda)> .
<#M> quo:hasSpectrum <#sigma(M)> .
<#M> sac:introducedIn
<http://link.aip.org/link/
doi/10.1063/1.3276419> .
<#M> dr:relatesTo
<http://arxiv.org/abs/
quant-ph/9611015#Theorem_1> .
```

Further examples of RDF abstracts for papers on quantum mechanics can be found on the *Link Your Research* project website[9].

4.2 Benefits

Let us now present probable benefits of applying Linked Data in quantum mechanic, and in physics

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[8] http://arXiv.org

[9] http://www.linkyourresearch.org/

in general. To this end assume that we have some collection of scientific papers on quantum mechanics. Today, only full text searching can be carried out on the papers (eventually, with the help of keywords). In the case when PACS (Physics and Astronomy Classification Scheme)[10] is used, searching for papers by subject is also possible. Assume now that for each paper RDF links are created and stored in a triplestore. Then, using SPARQL endpoint one could make various queries against the dataset. For example, in the case of RDF links created for papers related to time operator problem in quantum mechanics the following queries, among others, could be made:

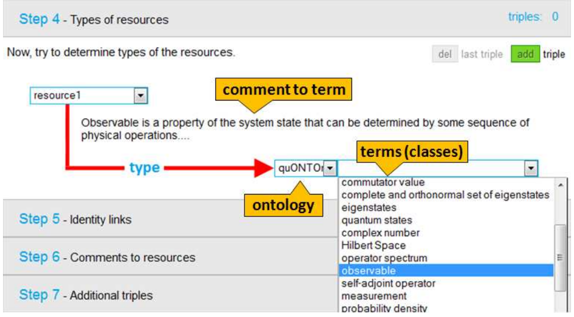
- *for some entities* e.g. self-adjoint time operators (`quo:SelfAdjointOperator`).
- *for properties of a given entity* e.g. for the type of spectrum (`quo:Spectrum`) of some operator (named with URI).
- *for a relationship between given entities* e.g. for the commutator relation between some two operators (`quo:CommutatorRelation`).
- *for entities with properties similar to a given entity* e.g. for time operators with a given spectrum (`owl:sameAs`).
- *for the article in which some entity was introduced* e.g. some time operator (`quo:introducedIn`).
- *for articles in which some entity is analyzed* e.g. some time operator (`sac:analyzes`).
- *for articles in which some entity is generalized* e.g. some quantum system (`sac:generalizes`).

It is obvious that possibility of asking such queries opens new opportunities for the retrieval of information in quantum mechanics. Scientific papers are no longer only human-readable data islands. They become in some part machine-understandable (at least in some part). There are precise relationships between papers and some entities described in them. Thanks to that as results of queries we will obtain concrete entities from scientific papers and not papers containing some string (as today).

5 LYR WEB TOOL

Linked Data for research papers on quantum mechanics has to be created manually by the research community, in particular by the author of a publication. Automatic creation of valuable and precise relationships between concepts and research papers seems to be out of scope of this domain due to its complexity. However, one can imagine tools supporting and simplifying creation of such data. We have developed a prototype of such web tool called LYR (Link Your Research)[11]. This tool supports creation of RDF links for any kind of publication which is available online. Such a publication is called in LYR a *context*. Each *context* has its URI identifier (usually it is a URL of the publication). A context corresponding to some publication contains RDF links created by the research community. In order to use the tool one has to register and possess a personal URI identifier. After simple registration one can create a new context or add links to already created contexts. The process of adding links has a few steps (including six steps described in Section 4) and consists of filling up a simple form available on the website. To this end one has to know terms from appropriate ontologies (see Fig.2). A user can choose ontologies he wants to use from available list. At present, there are only a few ontologies available however, new ontologies will be successively added (any user can suggest adding new ontology).

All RDF links generated using the LYR tool are stored in Virtuoso Open-Source RDF Triple Store[12]. The dataset obtained so far consists of a few hundred of links (RDF triples) generated for several dozen of research articles. Each article is available on the journal's website or at arXiv. Most of the articles are related to time operator problem in quantum mechanics. The reason for this limitation is the content of the ontology for quantum mechanics. In the actual version of the ontology only the most fundamental concepts and relations of the theory are represented, and the time operator problem is related to such fundamental concepts. The test dataset is gradually enlarged to include more links corresponding to various articles.



Step 4 - Types of resources

Now, try to determine types of the resources.

Observable is a property of the system state that can be determined by some sequence of physical operations....

Step 5 - Identity links

Step 6 - Comments to resources

Step 7 - Additional triples

Figure 2: LYR - adding links to a context.

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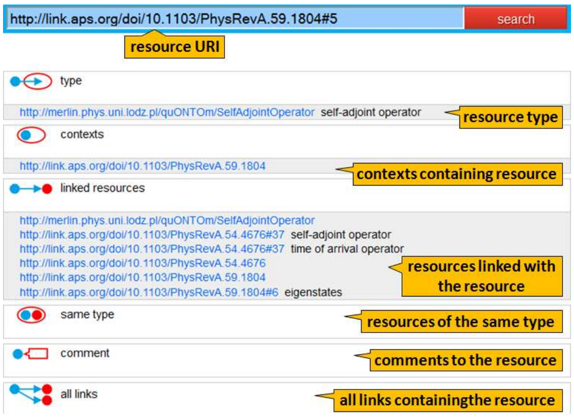
[10] http://publish.aps.org/PACS

[11] The tool will be available soon for tests. Please visit our project website for more infornation at http://www.linkyourresearch.org

[12] http://virtuoso.openlinksw.com/



http://link.aps.org/doi/10.1103/PhysRevA.59.1804#5

type
http://merlin.phys.uni.lodz.pl/quONTOm/SelfAdjointOperator self-adjoint operator

contexts
http://link.aps.org/doi/10.1103/PhysRevA.59.1804

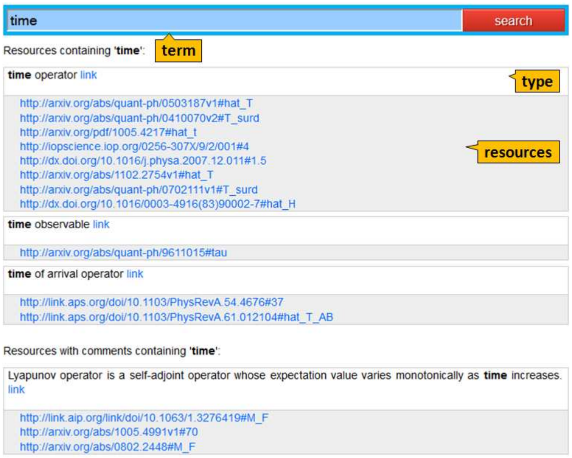
linked resources
http://merlin.phys.uni.lodz.pl/quONTOm/SelfAdjointOperator
http://link.aps.org/doi/10.1103/PhysRevA.54.4676#37 self-adjoint operator
http://link.aps.org/doi/10.1103/PhysRevA.54.4676#37 time of arrival operator
http://link.aps.org/doi/10.1103/PhysRevA.54.4676
http://link.aps.org/doi/10.1103/PhysRevA.59.1804
http://link.aps.org/doi/10.1103/PhysRevA.59.1804#6 eigenstates

same type

comment

all links

Figure 3: LYR - search for a resource.



time

Resources containing '**time**':

time operator link
http://arxiv.org/abs/quant-ph/0503187v1#hat_T
http://arxiv.org/abs/quant-ph/0410070v2#T_surd
http://arxiv.org/pdf/1005.4217#hat_t
http://iopscience.iop.org/0256-307X/9/2/001#4
http://dx.doi.org/10.1016/j.physa.2007.12.011#1.5
http://arxiv.org/abs/1102.2754v1#hat_T
http://arxiv.org/abs/quant-ph/0702111v1#T_surd
http://dx.doi.org/10.1016/0003-4916(83)90002-7#hat_H

time observable link
http://arxiv.org/abs/quant-ph/9611015#tau

time of arrival operator link
http://link.aps.org/doi/10.1103/PhysRevA.54.4676#37
http://link.aps.org/doi/10.1103/PhysRevA.61.012104#hat_T_AB

Resources with comments containing '**time**':

Lyapunov operator is a self-adjoint operator whose expectation value varies monotonically as **time** increases. link
http://link.aip.org/link/doi/10.1063/1.3276419#M_F
http://arxiv.org/abs/1005.4991v1#70
http://arxiv.org/abs/0802.2448#M_F

Figure 4: LYR - search for a term.

The LYR tool enables easy search and exploration of the dataset. One can search the dataset for all RDF links from some context, an entity (resource) from some publication (see Fig.3) or a term. In the last case as a result one obtains resources ”corresponding” to that term and not strings containing the term (see Fig.4). It is also possible to retrieve links between resources using SPARQL. Finally, it is worth to notice that requesting the linked data corresponding to some context is also possible. To this end one has to use the following URL:

`http://www.linkyourresearch.org/contextURI`

where `contextURI` is the URI of a requested context. When using this URL in a browser a web page containing all RDF triples from the context is loaded. In order to facilitate the creation of RDF links using the LYR tool a Firefox browser extension is developed. The extension will allow to see and add RDF triples for a visited research article (context).

6 DISCUSSION AND FUTURE WORK

In this preliminary paper we consider the Linked Data in the context of physics. In particular, we examine the possibility of representing physics data and knowledge according to the principles. We focus on research articles on quantum mechanics and show that it is possible to obtain Linked Data in those cases, using terms from appropriate ontologies. In particular, it is possible to link elements of the theory from two papers, not just documents containing these papers. There are, however, two important issues deserving attention. First, we want to stress that the obtained RDF links correspond only to part of human-readable data available in the articles. There are two reasons of the fact. Lack of the appropriate vocabularies - presented ontologies remain still under development. Another reason is that we are not able to represent advanced mathematical structures of the theory in RDF and OWL (Skulimowski, 2010). We also want to notice that automatic creation of RDF links for scientific publications in physics seems to be out of scope in this domain. The links has to be created manually by the research community. Taking this into account we are developing a web tool which support the creation. The tool is shortly presented in the paper.

Future work should focus on development of the presented ontologies. In particular, ’harmonization’ between the ontologies and others ontologies (e.g. Semantic Publishing and Referencing (SPAR) ontologies and SWAN Scientific Discourse Ontology may be required to remove overlap and conflicts. Moreover, it would be beneficial to provide general hints on how to create Linked Data for the case of research articles on physics. Thanks to such hints creation of Linked Data for a research articles could become a part of scientific activity and even a part of an editorial process in the future. The future development of the LYR tool should focus on increasing support during the creation of RDF links, for example automatic generation of URIs or suggesting links between resources. Moreover, visualization possibilities of RDF links stored in LYR should be extended. In future, care should be also taken to ensure consistency of RDF data created using the tool.

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SHORT PAPERS

Mathematics, Technology Interventions and Pedagogy

Seeing the Wood from the Trees

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Keywords: Mathematics Education, Technology, Classification, Guidelines.

Abstract: This research explores recent technological interventions in mathematics education and examines to what extent these make use of the educational opportunities offered by the technology and the appropriate pedagogical approaches to facilitate learning. In an attempt to address this, a systematic literature review has been carried out, and a classification is presented that categorises the types of technology as well as the pedagogical foundations of the interventions in which those technologies are used. The potential of technology to fundamentally alter how mathematics is experienced is further investigated through the lens of the SAMR hierarchy, which identifies four levels of technology adoption: substitution, augmentation, modification and redefinition. Classification of the interventions in this paper thus ranges from enhancing traditional practice, to transforming teaching and learning through redefinition of how tasks and activities are planned and carried out. The results of the research will be beneficial for guiding teaching, increasing our understanding of learning in a technology rich environment, and improving mathematics education.

1 INTRODUCTION

When mathematics teachers first consider the integration of technology into their daily class activities, they can be faced with an overwhelming array of devices, software, and instructional approaches, with no clear guide as to best practice. Hoyles and Noss (2003) highlight that the focus of research on digital technologies for mathematics education tends to concentrate on identification of the potential of a particular technology and the pitfalls or obstacles to its integration, and then discusses its mediation through activities, and the role of the teacher. The aim of this research is to gain some clarity regarding pedagogical approaches to technology interventions in post-primary mathematics education, as documented in recent literature, with the goal of generating an overview of the properties of interventions that are deemed to be successful. The main objectives are to increase the understanding of the kinds of teaching and learning of mathematics that technology has the potential to enhance and the generation of a set of guidelines for the implementation of such activities. A long-term goal is to create, and test, a pragmatic and comprehensive 21st Century model of classroom practice for mathematics education.

In order to address these issues, this paper first conducts a review of research that discusses issues and approaches to technology interventions in mathematics education. Following from this, the need for a system of classification is investigated, along with some existing models. A systematic literature review on a selection of twenty five papers that discuss specific interventions is carried out in accordance with the methodology discussed in section 4. The resulting data are analysed through the lenses provided by the emergent classification. A set of guiding principles for the appropriate use of technology in mathematics education is presented in the final section of the paper.

2 BACKGROUND

2.1 Pedagogic Approach

Many of the empirical studies examined for this paper are limited in that they concentrate on implementations of specific technology and do not focus on the more pragmatic issues around technology interventions that teachers require.

However, there is a clear trend towards a socially constructivist approach, indicating that technology interventions in mathematics education may be suited to an active and collaborative environment. This pedagogical theory has its foundations in the work of Kolb, Vygotsky and Bruner, and its positive effects have been borne out through the results of the longitudinal SPRinG study in the UK (Blatchford et al., 2003).

The emphasis on sense-making and problem solving, in particular in a social context, that becomes evident through the classification of the literature, informs the development of some of the guiding principles presented in this paper.

2.2 Further Areas of Consideration

Prior to the initiation of any intervention, it is of utmost importance to look at the circumstances under which learning can be enhanced by technology (Means, 2010). Oldknow (2009) suggests that the transformative potential of ICT is not restricted to new, or purpose built technology, but also lies in the innovative uses of everyday equipment.

Oates (2011) and Geiger, V., Farragher, R., and Goos, M. (2010) provide evidence that the outsourcing of computation through the use of technologies such as Computer Algebra Systems (CAS) has the potential to do more than just improve speed and accuracy. It can also provide increased opportunity for the development of investigative skills and problem solving.

Means (2010) and Oates (2011) highlight that if technology is to be truly integrated into teaching and learning then the assessment potential that it offers needs to be utilised where possible. Assessment can be administered through computer based testing, intelligent tutoring systems, use of collaborative documents or knowledge fora (Lazakidou and Retalis, 2010), or student devices networked to the teacher console (Noss et al., 2012).

It is also noted (Means, 2010) that teachers who actively facilitate and scaffold their students interactions with the technology are in a position to use their insights to refine the activities and inform instruction. In essence, the students' interactions with the technology can contribute to their formative assessment.

Innovation with regard to the working environment and class routine are seen as necessary in order to fully exploit the potential of technology in the teaching and learning of mathematics. Means (2010) points out that, contrary to popular belief, higher learning gains are evident when there is not a one-to-one relationship between the student and the technology, thereby encouraging collaboration and team-work.

Issues such as the professional development of teachers also emerge as essential for the successful integration of technology in educational settings, but these concerns are beyond the scope of this research

3 CLASSIFICATIONS

Classifications are not definitive descriptions, but should reflect a theory about the current situation; they should be dynamic and able to keep pace with the changes to the status quo. They should permit generalisation, and provide a basis for explanation of the emerging argument. In this case, the classification system is being developed to shed light on the current trends in technology usage in mathematics education, with a view to informing a set of guidelines for future interventions in the field.

Prior to the development of the classification of the literature presented in this paper, some existing systems were identified and considered. Four areas emerged as being of interest: technology, levels of adoption, learning theory and instructional approach. These will now be discussed in more depth.

3.1 Existing Classifications of Technology

The classification systems of Clarebout and Elen (2006) and Passey (2012) were considered, but were deemed unsuitable due to issues around relevance to mathematics and levels of complexity. Two classifications of technology for mathematics education by Hoyles and Noss however, are influential in this research. They are specific to mathematics education and, while being concise, provide an appropriate level of detail.

The first, (Hoyles and Noss, 2003) distinguishes between *programming* tools and *expressive* tools. Programming tools, such as microworlds, are defined as lending themselves to individual expression and collaboration. Expressive tools on the other hand, provide easy access to the results of algorithms and procedures, without the user being required to understand the intricacies of their calculation. The category of expressive tools is further broken down into pedagogic tools, designed specifically for the exploration of a mathematical domain, and calculational instruments, which are frequently adapted to, rather than designed for, pedagogic purposes. Dynamic Graphical

Environments, such as GeoGebra, are examples of pedagogic tools, and spreadsheet programs would fall into the category of calculational instruments.

In their later research, Hoyles and Noss (2009) classify tools according to how their usage shapes mathematical meanings. They refine and extend their previous framework differentiating between *dynamic and graphical* tools such as Cabri and Geometers Sketchpad; tools that *outsource the processing power*, of which computer algebra systems are an example; new *semiotic* tools, which may have the potential to influence how mathematics is represented; and tools that increase *connectivity*, such knowledge fora.

3.2 Emerging Classification of Technology

In this study, the classifications by Hoyles and Noss are further refined and amalgamated to provide the foundation for the technological component of the emerging classification. There is no evidence in the papers reviewed of semiotic tools that change the representational infrastructure of mathematics, and it has thus been removed from the presentation of the findings. Through the review of the papers it emerged however, that an extension of the Hoyles and Noss classification was required. The category of *toolkit* is therefore added as a distinct class. Integral to the definition of this new category is the design of technologies in accordance with a specific pedagogical approach, along with the provision of support for the student and the teacher through tasks and lesson plans, and feedback for assessment, all founded in the relevant didactic theory. Examples include Noss et al. (2009) and Tangney et al. (2010).

The technologies in the literature reviewed in this paper are thereby classified as follows:

- Outsourcing of Processing power
- Dynamic Graphical Environments (DGE)
- Purposefully Collaborative
- Simulations/Programming
- Toolkit

3.3 Classifications of Technology Adoption

Two perspectives on the adoption of technology in mathematics interventions were considered: the FUIRE model (Hooper and Rieber, 1995) and the SAMR hierarchy (Puentedura, 2006). While the FUIRE model provides information on an individual's use of the technology and their level of adoption of it in the classroom, the SAMR model is better fitted to describing the level of adoption present in a given intervention and as such, is the model selected for this classification of the papers.

The SAMR hierarchy (Figure 1) is broken down into the two broad categories of Enhancement and Transformation, each of which has two further subsections. The lowest level of Enhancement is classed as Substitution. This describes situations in which the technology is used as a direct substitute for the traditional method, without functional change as exemplified by the reading of classic texts online. The second level is that of Augmentation, in which the technology is used as a substitute for an existing tool, but with some functional improvement, e.g. if the text being read contains links to online study guides.

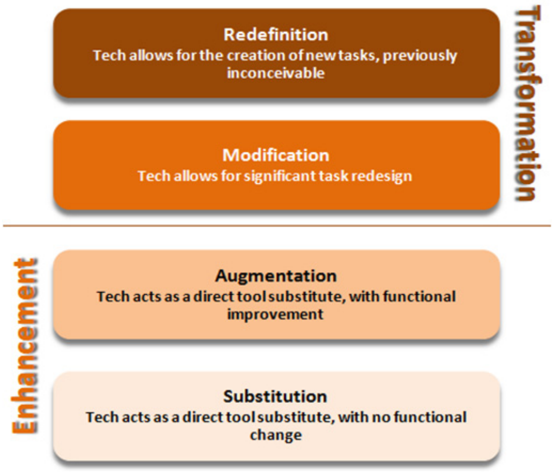

Figure 1: The SAMR Hierarchy (Puentedura, 2006).

The Transformation space on the SAMR hierarchy describes interventions that either significantly redesign the tasks provided through the use of the technology (modification), or that have used the affordances of the technology to design new tasks that would previously have been inconceivable (redefinition).

3.4 Additional Dimensions of the Classification

In addition to grouping the papers reviewed in this study by technology and level of adoption, this research also classifies them according to learning theory and instructional approach. These additional dimensions will now be expanded.

3.4.1 Learning Theories

The learning theories considered fall into two main camps: *Behaviourism* (Skinner, 1938) and *Cognitivism* (Bruner, 1977). Some cognitive learning activities can be further classified as *Constructivist* (Kolb, 1984), and within this, as *Constructionist* (Papert, 1980) or *Social Constructivist* (Vygotsky, 1978).

3.4.2 Instructional Approaches

The Instructional Approaches taken into account are:

- Drill and practice.
- Task Based.
- Individual work.
- Contextual.
- Inquiry.
- Plenary or whole class discussion.
- Realistic.
- Sense making.
- Active learning.
- Problem solving.
- Collaborative.

Most of the interventions examined adopted more than one instructional approach, with up to five distinguishable in some cases.

4 METHODOLOGY

The electronic databases searched in the review of recent literature were chosen for their relevance to education, information technology and mathematics: ERIC (Education Resources Information Center), Science Direct, and Academic Search Complete. The general search terms used were:

math* AND (technolog* OR tool*) AND education

These were used in an initial pass over the databases, and the results were then refined by limiters such as "secondary education". In order to further restrict results, only peer-reviewed, journal articles, issued between 2009 and 2012, were considered. A preliminary set of thirty four papers were selected for initial analysis, and of these, twenty five make up the final data set. The remaining nine papers were not included as they did not discuss specific interventions. However, a number of them did compare interventions in general and were useful in informing the set of guidelines that aim to describe a method of successful integration of technology in mathematics education.

5 ANALYSIS OF THE DATA

The data emerging from the literature review were coded and stored in a spreadsheet pivot table. This allowed the information to be arranged, related and visualised in diverse and meaningful ways. A summary of the classified papers is presented in scss.tcd.ie/~braya/csedu/The%20Papers.pdf.

Through this process, a number of interesting patterns became available. Figure 2 illustrates the clear socially collaborative trend in the literature, as well as the concentration on Outsourcing of Processing, and Dynamic Graphical Modelling Environments as the technologies of choice.

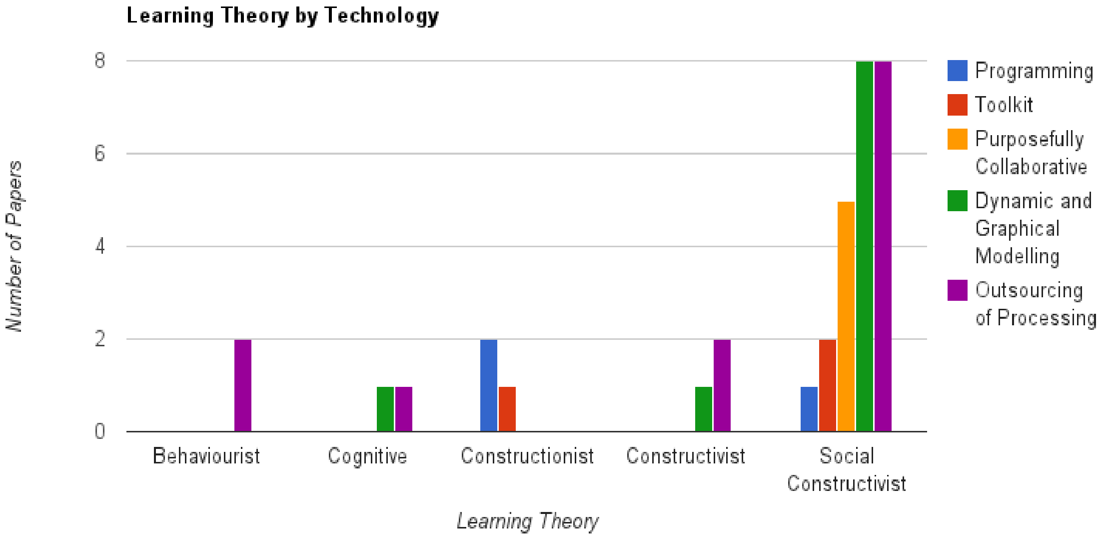

Figure 2.

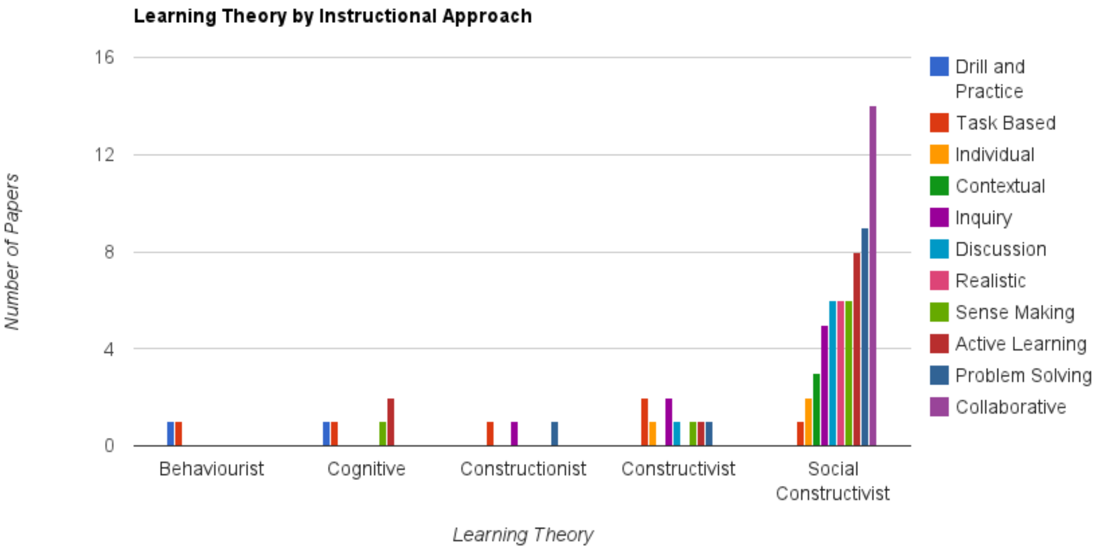

Figure 3.

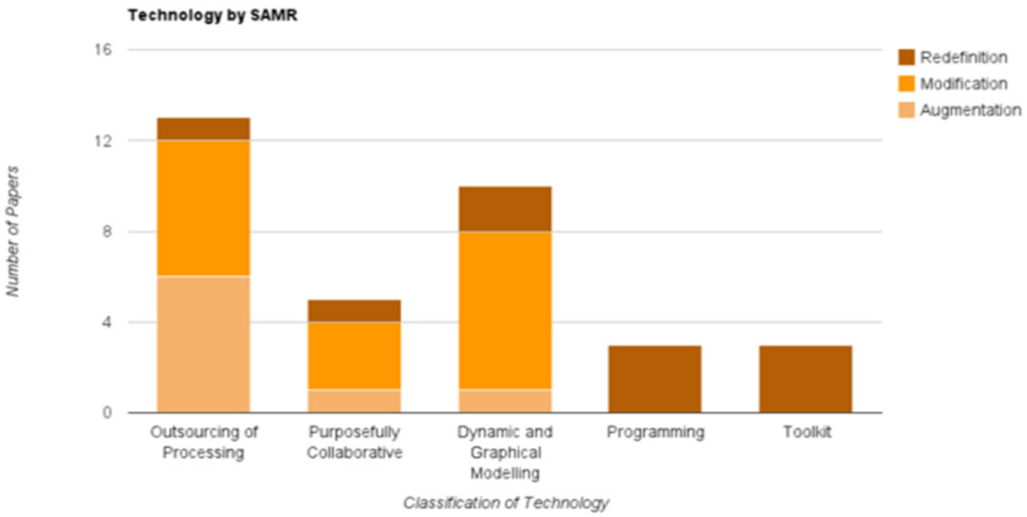

Figure 4: Technology according to SAMR hierarchy.

A correlation between instructional approach and learning theory also emerged from the data, as illustrated by Figure 3.

The interventions were also coded according to where they fell on the SAMR scale. It became clear that none of the papers considered dealt with technology as a direct substitute for traditional methods, without functional change (Figure 4). Roughly 30% fell into the sphere of *augmentation*, an example of which is the paper by Kay and Kletskin (2012), who evaluate the use of video podcasts in mathematics education.

Over 40% of the papers came under the heading of *Modification*, these include Ruthven, Deaney et al., (2009) analysis of the use of graphing software to teach about algebraic forms, and Lazakidou and Retalis' (2010) work on the use of technology supported collaborative learning strategies for problem solving in mathematics education.

The technology in each of the interventions classified in this way has facilitated significant redesign of the tasks and the learning experience.

Articles within the category of *Redefinition* make up the remaining 30% of the papers. These describe tasks and activities that would not have been possible without the use of the technology in question (e.g. Noss et al., 2012; Tangney et al., 2010). All of the studies that fell into the technology classifications of *programming* (e.g., Noss et al., 2012) or *toolkit* (e.g., Noss et al., 2009; Tangney et

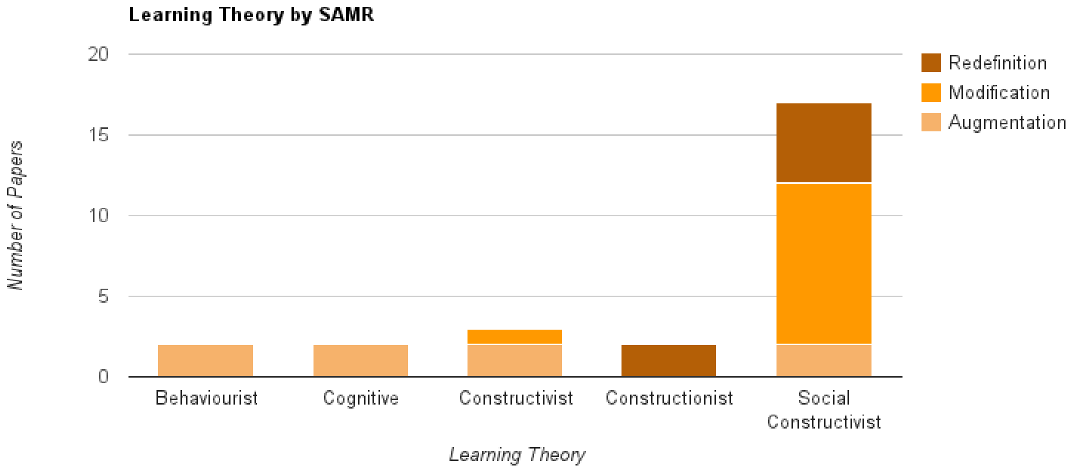

Figure 5: Learning Theory according to SAMR hierarchy.

al., 2010), are also classified under the remit of *redefinition*. Figure 4 illustrates the breakdown of the technologies according to the SAMR hierarchy, and Figure 5 indicates how the learning theories observed in the interventions are grouped in terms of the hierarchy.

6 DISCUSSION

Having looked at the general literature on uses of technology in mathematics education, this study took a structured approach, facilitated by a classification system, to analyse specific interventions.

It is interesting to note that all of the *constructionist* interventions use programming tools or toolkits (Figure 2), and are classed in the sphere of redefinition (Figure 5). The only other incidences of redefinition are seen within *socially constructivist* settings. Another interesting result is the lack of papers in the literature review that are classified at the level of Substitution on the SAMR hierarchy. There are a variety of possible reasons for this: one may be that while it is occurring in everyday usage of technology, it simply may not be reported in the literature. Alternatively, it is possible that the selection process of the papers under review was too narrow, an issue that will be addressed in future work.

Based on the general literature review and the classification of selected papers, a set of guidelines is now proposed outlining an approach to the design of learning experiences that fully employ the educational potential of technology and appropriate pedagogical approaches to facilitate learning. Interventions designed in accordance with these guidelines should significantly modify or redefine the learning experience through the affordances of the technology. That is, interventions of this type are likely to be classified within the Transformation space on the SAMR hierarchy.

6.1 Guidelines

An appropriate and innovative technology intervention in mathematics education should thus:

1. Be collaborative and team-based in accordance with a socially constructivist approach to learning.
2. Exploit the transformative as well as the computational capabilities of the technology.
3. Involve problem solving, investigation and sense-making, moving from concrete to abstract concepts.
4. Make the learning experience interesting and immersive/real wherever possible, adapting the environment and class routine as appropriate.
5. Use a variety of technologies (digital and traditional) suited to the task, in particular, non-specialist technology that students have to hand such as mobile phones and digital cameras.
6. Utilise the formative and/or summative assessment potential of the technology intervention.

7 CONCLUSIONS AND FUTURE WORK

Through the literature review and the development of a classification system, pedagogic approaches have been identified which are appropriate for use in technology enhanced teaching and learning. These are based in socially constructivist/constructionist learning theory and emphasise problem solving, investigative, and realistic instructional approaches. Use of assessment potential provided by the technology and flexibility with regard environment and class routine also emerged as important aspects of a successful intervention. From this data, a set of guiding principles were extracted that have the potential to form the basis of a 21^{st} Century model for the integration of technology into mathematics education.

In order to gauge the efficacy of the guidelines, initial exploratory interventions are being developed. As part of this, a number of pilot activities have already been implemented, with very encouraging results.

Further studies which implement the guidelines will be used to build up a strong evidence base for the potential of such activities to enhance mathematics education. Such activities will require execution in traditional school settings as well as purpose designed environments, in order to investigate their potential to scale.

The literature review will continue to be expanded in order to confirm the results and keep the system of classification up to date. This will be an iterative process and will, along with the results of the studies, continue to inform and refine the guidelines.

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Interactive Lessons for Tablet-based Teaching
A Proposal for an Open Data Format

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Keywords: Tablets, Schools, Teaching, Interactive, Android, iPad, Multimedia, Math, Foreign Languages.

Abstract: Tablet devices like the Apple iPad are ideal for interactive learning content. Unfortunately, at the moment it is still quite difficult for authors to create interactive content. There are very few standards in the area of tablet computing, in particular, if authors do not want to restrict themselves to a single platform e.g. iOS or Android. In this paper we propose an open data format, which makes it easy for authors to create interactive content. We achieve this by separating content description from the visual appearance and behaviour. Thus, allowing to create interactive content without the need for complex tools or even programming skills. The data format may be implemented for any of the leading platforms. Thus, giving content creators the control over the usage and the distribution of their content.

1 INTRODUCTION

Computing devices are becoming more and more popular in education. While previous efforts like the One Laptop per Child project by Negroponte et al. (Negroponte, 2006) have seen some success, there are now two trends which are about to change our education systems and our way of doing education.

These trends are, on the one hand, the field of online learning and on the other hand tablet-based teaching with devices like the Apple iPad or comparable Android tablet devices. Both fields are very new, but exciting progress has been made in the past year.

In the field of online learning, we have seen the first courses with tenths or thousands of participants, something which was unimaginable a decade ago. The Stanford university with their professors Thrun and Norvig have been pioneering in this domain with their artificial intelligence class (Thrun and Norvig, 2011). Since then we have seen the appearance of online universities like Udacity (Thrun et al., 2012) and Coursera (Ng and Koller, 2012).

Tablet devices have only been available for less than two years. Yet we see a large number of deployments at schools in North America and Europe, for example (Farias, 2011; Klinga, 2011). Touch-based interaction is very well suited for educational content and both teachers and students have been quite enthusiastic about the new possibilities.

Figure 1: Main screen of the developed tablet software for high school students.

While these developments and adoption of new technology is certainly welcome, standards have yet to be established. In the field of online learning e.g. each individual player (e.g. Coursera, Udacity) has its own teaching style and platform. For tablet-based teaching, there are standards for electronic Books (e.g. ePub, iBooks), but as far as truly interactive content is concerned there are no established methods, learning styles or data formats available.

Based on our experience from tablet deployments at various schools in Germany, we propose both a new learning style for tablet-based teaching and an extensible open data format, which may be freely implemented by educators.

Our proposition of a new learning style is discussed in detail in a separate paper (Weible and Seemann, 2013). The contribution of this paper is therefore the proposal of a novel data format tailored towards the requirements and properties of tablet-based and online teaching. Our goal is to facilitate the distribution of interactive learning content to all platforms (e.g. iPad, Android, Windows).

In the following we will first discuss related projects, then continue to describe requirements for tablet-based learning content. We continue with the specification of our open data format and conclude with an outlook on future developments.

2 RELATED PROJECTS

The fields of online and tablet-based learning are both rather new. Historically online learning started with the distribution of conventional books and lecture notes over the internet. Demonstations e.g. via Java-Applets followed, but remained limited in scope. In particular, there existed very few truly multimedia or interactive content which covered a larger topic.

With the appearance of online video services like e.g. Youtube online learning shifted to providing video lectures. In the beginning, these lectures often were simple recordings of traditional university lectures. With the success of Salman Khan's video tutorials on Youtube (Khan, 2006), the community realized, that a different learning style is necessary and that videos should be much shorter.

Only recently, we see interactive courses, which combine short video clips with online questions and exercises. In particular, the online universities Coursera and Udacity (Ng and Koller, 2012; Thrun et al., 2012) use this new online learning style. Even though these platforms build on web technologies, there is no common data format underlying these courses. It is also not possible to work with the interactive material when no internet connection is available. However, we start to see cooperations on data format and platform usage. Most importantly edX has recently been founded as a joint project by MIT, Harvard, UC Berkeley and the University of Texas.

Google has also recognized the need for a common platform and recently released a course builder to create online courses (Google, 2012).

For tablet-based teaching there are even less common standards available. Firstly, there is no established learning style and publishers seem to feel a distinct uncertainty how tablet-optimized content should look like. Moreover, the competing platforms (iOS, Android) require both educators and publishers to make a choice which to support. The past two years have been too short for researchers to tackle the problem and there is unfortunately very little research available (see e.g. (Isabwe et al., 2012)). We see, however, two developments. On the one hand there are data formats for electronic books (e.g. ePub, iBooks). On the other hand, interactive educational apps appear, which cover a certain educational topic.

While iBooks is a specified standard which may be used by publishers and educators, it has various restrictions. Firstly, it is a proprietary standard, which cannot be adapted or extended to support additional features. Secondly, distribution is exclusive to Apple's Appstore for iOS devices. Publishers in some countries have therefore been reluctant to Apple's iBooks standard. Interactive educational apps, on the other hand, share no common learning style or data. They are also difficult to develop and differ very much in terms of user experience. A common standard data format along with a reference implementation would be certainly welcome by many educators.

3 REQUIREMENTS FOR TABLET-BASED TEACHING

Tablet devices provide a set of benefits compared to both desktop computers and laptops. First, they are typically smaller and easier to handle. This is not only true for the actual hardware, but also the included software.

For the learning experience touch screens are crucial since they allow more natural and quicker interaction with the device. A survey conducted after the first months of our tablet deployments clearly showed this. In fact, we were surprised by how few students missed a physical keyboard or mouse (Weible and Seemann, 2013).

Based on the experiences from online learning and the positive effect of touch interaction, we believe that learning content for tablets should exhibit the following characteristics.

Content should be divided into small manageable parts. It should be presented in a way, which allows the student to see, hear and interact with the content. The interaction is accomplished via touch-based exercises or questions. An example, could be a cloze procedure, where possible responses can be dragged into position with finger touches.

Content Creation. In some sense, developing such interactive content is quite similar to game development. In order to allow educators to create content without special knowledge like programming skills, we need a data format, which abstracts this complexity. That is, the educators define the content only. The behaviour may be created in a reference implementation by a programmer. Thus, educators can reuse these reference implementations for different styles of exercises and questions (for more detailed information see section 4).

A common open data format would allow educators to share their content and remix other existing contents. Additionally, programmers could provide implementations for various operating systems or adapt the visual appearance and behaviour of the content to improve the learning experience.

Offline Content. Another hurdle for the deployment of learning content in schools is the lack of internet connection. Even in developed countries internet access in every classroom is not available. Thus, learning content needs to be available offline, which eliminates the use of many great online resources. Again, if the content, which is available online would be in a standardized format, it could be easily transfered to tablet devices (this applies to free content e.g. released and creative commons licenses or paid content).

Self-learning. Tablet-based teaching should focus on self-learning. That is, students should be able to work through the content on their own. As it is the case for online learning (e.g. Udacity, Coursera) this will drastically change who can participate in education and what students are able to learn. In our opinion, this is one of the greatest strength of tablet-based teaching to empower the students to better learn for themselves.

4 PROPOSED DATA FORMAT

As pointed out in the previous section the data format should describe the actual content. The visual appearance of this content is part of a reference implementation, which is independent of the underlying data format. That is, similar to a graphics format, which may be displayed with various image viewers.

The design of our data format follows the subsequent design goals.

Interactive Content should be Easy to Produce. For educators it is hard to produce multimedia content. They have to record audio, video and subsequently process this raw material. This often requires complex software (e.g. video editing software), which combines video, audio, images and text. The involved software is not only difficult to learn, but the content generation is a time-consuming process.

It is getting even more difficult, when the content should be interactive. In online scenarios, this is mostly accomplished through programming via e.g. HTML5/JavaScript, Java Applets or Adobe Flash.

In order to allow the generation of multimedia and interactive content with minimal effort, our data format divides content in small chunks or frames, which can be described through simple text. These frames may contain videos, images, audio and even interactive exercises.

All content within such a frame is played at once. That is, on opening the frame e.g., the text is displayed and read to the student and an additional visualization in the form of an image or video is displayed.

An example would be:

```
(01) Not far from River Rhine, not far
 from the Swiss town Schaffhausen is a
    small cave called "Kesslerloch".
        <Kesslerloch.jpg top>
```

Here the number `(01)` specifies the frame number. It is followed by a text, which will be displayed on the screen. An audio track which possibly reads this information to the student does not have to be specified explicitly. Since the audio belongs to a specific frame, we can associate its file name with the frame number. In the above case `01.mp3`. In many cases, e.g. foreign language education, the content author and the speaker are not the same person. The above naming convention allows both content authors and possible speakers not to worry about file names. Associated media files are specified in brackets. Here a JPG file is used as an illustration at the top of the frame.

Note, that the splitting in more manageable frames also removes the need of alignment of media files and text, which typically requires a lot of effort in video editing.

Obviously, such a simple format restricts the possibilities a teacher has, when creating content. This is intentional. On the one hand, we want the content to be clean, i.e. there should not be an overflow of information or clutter. On the other hand, there is a trade-off between simplicity and speed of creation and flexibility. As we will see in the subsequent paragraphs, however, the data format contains a set of predefined templates, which can be used. Thus, allowing a wider variety of ways to present content and to include interactive elements.

Note, in particular that the content may even be created without the need for a development environment with a standard text editor.

Data Format should be Human Readable. All content should be described in human readable form. This has various advantages. Firstly, it allows a speaker to read through the data files and record the respective audio tracks without special tools. A foreign language teacher can e.g. create a lesson, save it in the above data format and have a native speaker dub the content. Note, that content, which needs to be skipped by the speaker is always in parantheses (e.g. the frame numbers or the media files). XML files, which are often used for data storage are mostly human readable as well, but they are visually much harder to process by the human eye. This is especially true for speakers, which are typically not familiar with XML, at all.

The XML and other file formats are optimized to make it easy for a computer to process the data. In our file format, we want to make it easy for humans (either authors or speakers) to create and process the content. In some cases, this means, that a parser for the format is slightly more complicated to implement, but that is a one time effort. whereas content generation is a continuous process.

For our deployments at high schools in Germany (Weible and Seemann, 2013) we have already created a parser and reference implementations of a learning environment based on this data format for all major platforms (iOS, Android, Windows).

4.1 Interactive Elements

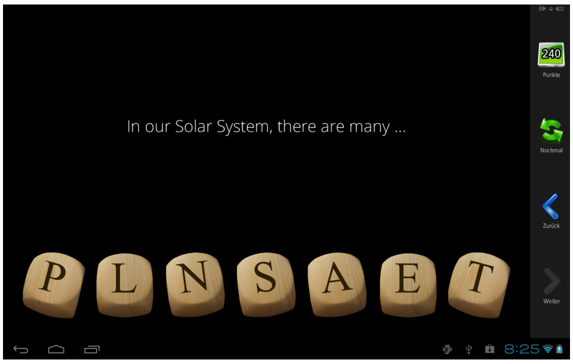
Our data format describes a set of interactive elements, which may be used by content creators. Again, the actual visual implementation is part of a reference implementation, not of the data format itself.

Shuffled Letters. The first type of interactive exercise is called shuffled letters. It is intended to better recall newly learned words and to remember their spelling. The main application is in the area of foreign languages, but it is also applicable to learn terms in the fields business or engineering. An example for the description of such an exercise is depicted below:

```
(02) In our Solar System, there are many
                    ...
  -> Correct!  In our Solar System there
          are many *planets* .
```

From the above data, the computer automatically generates an anagram of the solution, which is in this case the word "planets". The student has to then to use touch interaction to reorder the different characters.

The corresponding frame as implemented in our own reference implementation looks as follows:



In our Solar System, there are many ...

Remember, the design goal has been to make it easy to create content. In this case, an author just has to provide a sentence, which needs to be completed (denoted by the ellipsis). The success message starts with an text arrow. This part is, obviously, only displayed once the student has found the correct solution. The corresponding audio tracks need to be stored in files named `02.mp3` for the first part and `02b.mp3` for the success message. If an audio track for the success message exists, the message will not be displayed, but only read to the student. The correct solution is specified in the success message by surrounding it with stars. The same technique is commonly used in e-mails to highlight a word. As can be seen, it is extremely easy and fast to create such an interactive exercise with the above scheme.

Shuffled Words. In a similar way, we can create other exercises like shuffled words. The main application here is to learn the grammar of a foreign language by bringing the words of a sentence into the correct order. For this, we specify the words or parts of the sentence in square brackets and separate them by commas. Alternatives from which a student has to choose (e.g. does versus do) are defined by a slash.

An example is:

```
(03) [how, long, does/do, the journey,
          take/takes]
  -> Correct!  The answer is *how long
       does the journey take*
```

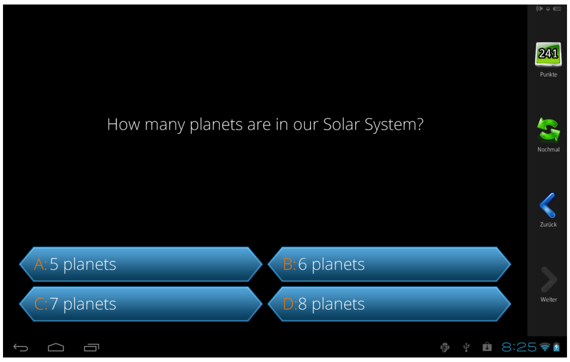
Note again that the author does not have to shuffle the words manually, as the computer can shuffle them automatically at run-time. This procedure is also less error-prone, since it makes the exercise more readable for the author. When shuffeling words manually, authors sometimes tend to forget to specify one of the words in the sentence.

Multiple Choice Multiple choice exercises are the most commonly used type of question. In our data format the questions may be specified in the following manner:

```
(04) How many planets are in our solar
            system?
          - 5 planets
          - 6 planets
          - 7 planets
          - 8 planets
   -> Our solar system contains *8
     planets*.  You're right!
 -> There are actually *8 planets* in
our solar system.  Mercury, Venus, Earth,
    Mars, Jupiter, Saturn, Uranus and
            Neptune.
```

Note, in particular, that there are two lines starting with text arrows. Next to the success message, a result message is added when the student has picked the incorrect answer. Following our naming scheme for the audio tracks, a speaker would store the question text in a file `04.mp3`, and the two result messages in the files `04b.mp3` and `04c.mp3`.

In our reference implementation, the above question is displayed as follows:



How many planets are in our Solar System?

A: 5 planets
B: 6 planets
C: 7 planets
D: 8 planets

Numeric Computations. In math education as well as in other technical disciplines, most exercises require the user to enter the result of a numeric computation. This application is also specified in our data format.

An example would be:

```
   (05) Marc is giving two pieces of
chocolate to his brother and keeps three
          pieces for himself.
       3 pieces of 5 pieces = ?%
    -> Correct!  He is keeping *60*%.
-> Try again, 50% are half of the pieces
    and four pieces constitute 80%.
```

Again, it is extremely easy for an author to create such an exercise. A question mark with a leading white space character is used to indicate, that the student should fill the answer at the corresponding position. For tablet devices a custom virtual keyboard is displayed to allow the student to conveniently enter the result.

Further Elements. In a similar fashion further interactive elements can be specified e.g. fill in the blanks style exercises. We have currently integrated twelve styles of exercises and plan to expand this in future versions.

The full specification and feature set of the first version of our data format will be finalized and released to the public on http://scoolbook.org.

5 CONCLUSIONS

Tablet-based teaching will become pervasive in the next few years. There is demand for content, which is tailored towards this new style of teaching and self-learing. Currently, there is no standard for this new type of content. In this paper, we have proposed a simple, open data format, which may be adopted by authors to create interactive content.

The format is extremely easy to use and implement. In various tablet deployments at schools in Germany, we are already working with a reference implementation for this data format. Our feedback from teachers working to create new content has been very positive. In fact, interviews with authors has shown, that especially non-technical authors very much prefer this format over XML-based formats.

We encourage the community to contribute further ideas for this data format, create content based on it and adopt it in other deployments.

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How to Design Good Educational Blogs in LMS?

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Keywords: e-Learning, Web Page Design, Educational Blogs, LMS, Blogs Criteria.

Abstract: Social communication tools in E-Learning have seen monumental growth in the last decade. Blogs as one of the most important tools have a huge contribution in social communication in Learning Management Systems (LMS), and the majority of research incorporating blogs in LMS reveals the effectivity of them. Thus, the quality of blog design becomes the main factor that determines the success of educational blogs. Although a literature review of guidelines and web page standards contain a variety of categories to cover most features of web page design, not all of them can be used to create an effective blog. There is a need to further explore these technologies in educational contexts and identify the criteria of combining them in unit design. The main purpose of this paper is identifying the educational blogs criteria by analysing the literature, research and the reviews of experts in the field. The study outcomes include the final list of blogs criteria which are classified into 6 categories and 80 indicators.

1 INTRODUCTION

A weblog is defined in short as a personal website that usually provides the opportunity to discuss topics with historical entries that are as a rule brief and often include subjects' summaries and links on the blog as well as personal opinions and recommended references. Photo and video blogs are blogs with posts of pictures and videos, respectively, supported by text (Vaezi et al., 2011); (Shih, 2010); (Tekinarslan, 2008). Pedagogical blogs have many advantages, such as self-editorship, free space to present students' view, quick and easy updates, free access to the discussion topics and indexing (Ko and Pu, 2011); (Farmer et al., 2008). Moreover, students can be encouraged to discuss what interests them, and can post their personal comments on other students' blogs. (Ozkan, 2011); (Reupert and Dalgarno, 2011); (Farmer et al., 2008).

On the one hand, some researchers focus on exploring the factors influencing blogging interaction (Ko and Pu, 2011); (Kuzu, 2011); (Vaezi et al., 2011); (Wu and Wu, 2011); (Hourigan and Murray, 2010); (Al-Ani et al., 2008); (Burke and Oomen-Early, 2008); (Chong, 2008). All results support the new trend in e-learning and effective blogging as communicative tools for both individual self-expression and provide free space for students to learn and interact.

On the other hand, Saeed and Yang (2008), reported that, 40.7% of the students never participated in blogging activity, and 70% of all participations shared only one post per week. Stone (2012), were analyzed 505 blogs results indicates that not all students completed each of the 15 blogs task requested of them, only 57.1% of the total entries (885) were actually posted by students. The purpose of this paper is identifying a set of blog criteria based on web page design guidelines and blog literature. These criteria will assist students in improving interaction among themselves and will help e-learning designers in developing more effective blogs in LMS. We present the details of a study conducted to identify educational blog criteria in LMS. This study consisted of three phases. The first phase was a thorough literature research to collect the initial list of blogs criteria. The second phase was the classification of the blogs criteria in six categories with specific indicators. The last phase was to conduct a survey with experts in instructional technology and e-learning to evaluate the importance of the proposed blogs criteria.

2 EDUCATIONAL BLOGS

Educational blogs are quite different from traditional web pages, and they need more specific criteria to ensure that can be used effectively in an e-learning platform (Tan et al., 2010). We conducted a detailed literature review to collect blog criteria. These criteria are then classified in six main categories that we discuss in some detail in the next sections.

2.1 Blog Design

Design features refer to how blog look and feel. This study found three elements for design: font, color and frames. Font is one of the main factors affecting blog design. Font should be visible without having to install new fonts. Moreover, color in educational blogs is used not only to make blogs more attractive, but also to improve readability and focus on the specific information in the blog (Vaezi et al., 2011); (Tarasewich, 2008); (Viehland and Zhao, 2008); (Yousef, 2008); (Powell, 2002); (Nielsen, 2002); (Nielsen and Tahir, 2001); (Gibbs et al., 2000); (Lee and Boling, 1999).

2.2 Navigation

The navigation style helps students to achieve their blog objective. It is important that students are able to find the navigation feature easily (Wu and Wu, 2011). Good design of navigation tools help students to find the important topics and discussion via blog effectively. In this study identified three components links, menu and search box (Tan and Tan, 2010).

2.3 Media Use

Multimedia is an extra option for students and teacher (Derry, 2007). It can be defined as the incorporation of communication media such as image, audio and video in the blogging to present information (Crozat et al., 2007); (Hartsell and Yuen, 2006); (Bijnens et al., 2004); (Leidig, 1999).

2.4 Usability

According to the International Standards Organization (ISO) web usability is defined as "the extent to which a site can be used by a specified group of users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (Wu and Wu, 2011); (Tse et al., 2010); (Whitehead, 2006); (Nielsen, 2002).

2.5 Content

A good content design not only improves the learners' attention and increases their performance, but also improves their knowledge and skills (Schoneboom, 2010); (Krunić and Ružić-Dimitrijević, 2008); (Rieh, 2002); (Lee et al., 1996).

2.6 Accessibility

The purposes of accessibility are that students can perceive, understand, navigate, and interact with the blog, and that they can browse all content available on the blog and meet different technical needs to support loading speed, download ability and compatibility with major browsers (Ozkan, 2011); (Ha et al., 2007); (Hassan and Li 2001).

3 STUDY RESULTS AND DISCUSSION

In this study, we grouped the list of 80 indicators in 6 categories and 19 main criteria. We then conducted a survey in which we asked 19 e-learning and instructional technology experts to rate each indicator on a 5-point Likert scale from not important (1) to very important (5). The evaluators could also use a decimal value like (3.75). The statistical results of this survey show that the most important categories were accessibility and navigation, while the least important ones were blog design and content. In the following sections, we discuss the results of this study based on each category.

3.1 Blog Design

Blog design category included three main criteria with 13 indicators. See Table 1.

Table 1: Blog design category (N=19).

Blog Design Indicators	**M**	**SD**
1. Use commonly-supported font styles (e.g., Times New Roman, Arial, Calibri, and Arial Black).	3.54	0.926
2. Titles/Headings font size (16 to 24) Bold.	**3.29**	**0.783**
3. Body text font size (14 to 20) Normal.	3.45	0.872
4. Don't use more than 3 font types in the same Blog.	3.89	0.792
5. Use high-contrast text and background colors so that type is as legible as possible. For Ex (Black text with White Background).	**4.34**	**0.726**
6. Using mixture of upper and lower case for text.	3.62	1.158
Font Indicator means average	3.69	
7. Sharp color contrast between background and foreground.	3.86	0.843
8. Use color for different functional area (Title, Menu and hyperlinks).	3.63	0.915
9. Use of light color (white / yellow) for background.	3.25	1.070

Table 1: Blog design category (N=19) (Cont.).

Blog Design Indicators	**M**	**SD**
10.Minimum 2 color, Maximum 4 color except for photo and graphic.	3.71	0.680
11.Color can be used to highlight text or graphics to make them stand out.	3.68	0.798
12.Avoid the use of complementary colors (e.g., blue/orange, red/green, violet/yellow)	3.50	1.054
Color Indicator means average	3.60	
13.Use templates rather than frames to avoid confusing users, or if frames are used, be sure to title and label them to identify areas of changing information	3.39	1.021
Blog Design Indicator Average means	**3.63**	

In the statistical results font is ranging between M=3.29 and 4.34 which indicate that experts accepted these indicators. High contrast between text and background is a critical issue that may influence the value of blog. The second high mean of this category is Color and Background with a range of M=3.25 to 3.86. As well as, the third criteria frames obtain M=3.39.

3.2 Navigation

The navigation category included three main criteria with 11 indicators. See Table 2.

Table 2: Navigation category (N=19).

Navigation Indicators	**M**	**SD**
14. Begin links with the information-carrying word, because users often scan through the first word or two of links to compare them.	3.61	0.926
15. Clearly identify items that are links by using visual cues (e.g., underlining, a change of item color when cursor is hovered, or a change of cursor image on hover, etc.	4.18	0.831
16. Accurate and up-to-date links.	**4.64**	**0.548**
17. Links should lead directly to the detailed page for the discussion topic.	**4.42**	**0.765**
18. Input boxes should be wide enough: Allow enough space for at least 30 characters in the font size used by most of the users.	4.05	0.705
Links Indicator means average	4.18	
19. Menu / List of contents on each page of blog.	4.08	0.765
20. Menu includes blog map.	**3.37**	**1.179**
21. Using simple design for menu.	4.22	0.815
22. Navigation located in the same place of each page of blog.	**4.68**	**0.436**
Menu Indicator means average	4.09	
23. Give users an input box on the blog to enter search queries, instead of just giving them a link to a search page.	3.97	1.019
24. Search box should be placed at the top of page, left or right of the blog.	3.89	0.981
Search Box Indicator means average	3.93	
Navigation Average	**4.10**	

According to the results in this table, it can be clearly seen that indicators 16, 17, 15 and 18 obtained the highest mean scores of 4.64, 4.42, 4.18 and 4.05, respectively, which indicated that experts give the helpful links high level to support students to be able to find more information and navigation feature easily. The second point to note is indicators 22, 21 and 19 obtained the highest mean scores of 4.68, 4.22 and 4.08 respectively that referred to importance of a menu design features such as simple design, including a list of content to improve the students, navigation.

3.3 Media Use

The media use category included three main criteria with 16 indicators. See Table 3.

Table 3: Media use category (N=19).

Media Use Indicators	**M**	**SD**
25. Control features for audio file where appropriate, for example, Play, repeat, volume, stop and pause.	3.89	0.897
26. The sound shall be audible and intelligible.	**4.24**	**0.978**
27. Easy to download.	4.00	1.076
Audio Indicator means average	4.04	
28. Minimum Video resolution (Pixels) 320 * 240.	3.68	0.892
29. Standard Video format be offered as a “HTML5-compatible video”.	3.89	0.804
30. Use short video clips, No more than 15-minute clips.	4.08	0.799
31. Avoid rapid cuts or changes of scenery.	3.29	1.092
32. Keep videos small for easier transfer, e.g., to up to 10 M.B.	3.92	0.892
33. Control features for video clip where appropriate, for example, Play, repeat, full screen, slowdown, stop and pause.	**4.21**	**0.713**
Video Indicator means average	3.85	
34. Use graphics / Images for emphasizing the information.	**4.50**	**0.688**
35. Use graphics / Images for attracting attention.	3.87	0.856
36. Using “thumbnails” for showing large images.	3.95	0.816
37. Using small images to be easy to loading.	3.91	0.648
38. Make sure all the key components of the graphical images are labeled.	3.76	1.002
39. Use simple and clear images; avoid images with too much detail.	3.61	1.008
40. Use graphics to show real content, not just to decorate blog.	**4.51**	**0.588**
Image Indicator means average	4.01	
Media use means average	3.96	

Audio indicator 26 and 27 obtained a high mean score of 4.24 and 4, respectively, indicating that audible and intelligible sound is a pivotal indicator that may influence the effectiveness of audio blogs in LMS. Moreover, Image criteria indicators 40 and 34 obtained a high main score of 4.51 and 4.5, respectively, indicating that image can be a source of information, learning and present every bit as powerful as the written text. Furthermore, Video indicators 33 and 30 obtained a high mean score 4.21 and 4.08, respectively, that refers to the importance of control features for video clip and using short video clips is a crucial indicator that may influence the effectiveness of video blog learning.

3.4 Usability

The usability category included two main criteria with 8 indicators. See Table 4.

Table 4: Usability category (N=19).

Usability Design Indicators	M	SD
41. Include some information how to use this blog.	3.76	1.105
42. Include some recommendation about search and old posting finding.	3.82	0.831
43. Help link should be available.	3.97	1.175
Help Indicator means average	3.85	
44. Blog length should be no longer than 2 screens.	3.38	1.013
45. Make sure the important content is visible at a 800 * 600 resolution without having to scroll.	3.87	1.024
46. Design should be simple and uncluttered.	**4.50**	**0.743**
47. Include a tag line that explicitly summarizes what the blog does.	**4.14**	**0.792**
48. Avoid horizontal scrolling at 1024x768. Horizontal scrolling invariably causes usability issues, the biggest being that users don't notice the scrollbar and miss seeing content that is scrolled off of the screen.	**4.08**	**0.831**
Layout Indicator means average	4.0	
Usability Design Indicator Average	3.94	

The most noticeable thing is that blog layout indicators 46, 47 and 48, obtained the high mean scores of 4.50, 4.14, and 4.08, respectively, which indicate the importance of a simple and uncluttered of blog.

3.5 Content

The content category included five main criteria with 22 indicators as listed in Table 5.

Blog authority obtained high mean scores ranging from M= 4.16 to 4.58, which indicate that the important of copyright issue for the content. Moreover, blog information indicators 64, 62 and 63 obtained a high score mean of 4.29, 4.21 and 4.14, respectively, indicating that content of a blog should be free from spelling, grammatical, or syntax errors, and typos. The blog scope indicator 49 obtained a high mean score (M= 4.34) which indicating that, the important of clear title. Furthermore, the blog objective indicator 56 obtained a high score mean

Table 5: Content category (N=19)

Content Indicators	M	SD
49. Blog title should attract the audience and be easy to understand, and clearly convey the purpose of the blog.	**4.34**	**0.563**
50. Include a short description of the topic in blog title.	3.98	0.729
51. Blog information should be depth of subject coverage.	3.67	0.833
52. Blog should be intrinsic value of information.	3.86	1.008
Blog Scope means average	3.96	
53. Blog must give references or sources of the information.	**4.58**	**0.591**
54. Copyright holder statement.	4.18	0.935
55. Comments should be reviewed and ensured that they are correct.	4.16	0.859
Authority means average	4.31	
56. Blog should be standing clearly goals /aims.	**4.18**	**0.782**
57. Invite students to set their own goals for blog usage - above and beyond a quantity measurement.	3.95	0.999
58. Information should be presented in an objective manner.	3.53	1.045
59. Use the “Bloom Taxonomy” instructional objective design.	3.38	0.853
60. Each blog should have at most three objectives.	3.18	1.003
61. Each objective should focus on only one task.	**3.00**	**1.136**
Objective means average	3.54	
62. Blogs content must be free from spelling, grammatical, syntax errors, and typos.	4.21	1.068
63. Sequence of lessons information and instruction are logical and clear.	4.14	0.880
64. Blog must be written at a level appropriate to the reader of the content.	**4.29**	**0.878**
65. The content is informative.	4.00	0.960
66. Separation between information and opinion content.	3.93	0.772
67. Choices of media type for information, for example, text only, audio or video.	3.79	1.058
Information means average	4.06	
68. Blogs body should be a goal, not a fixed rule: a paragraph should preferably not have more 6 sentences.	**3.03**	**0.950**
69. Heading and bulleted lists are used so that content can be easily scanned.	3.84	0.862
70. Use the typography and skimming layout, for example, bold font and highlighted words.	3.76	0.996
Scanability means average	3.45	
Content means average	3.75	

M= 4.18 indicating the importance of clear blog aims to increase the influence of blog content value.

3.6 Accessibility

The accessibility category included three main criteria with 11 indicators as listed in Table 6.

Table 6: Accessibility category (N=19).

Accessibility Indicators	M	SD
71. Blog does not take a long time to load.	4.39	0.836
72. Blog provides a "help feature" or instructions on its use.	3.74	1.093
73. Blog does not require special "plug-ins" or other types of special viewing helpers. If it does, this is clearly indicated.	**4.16**	**1.001**
74. Ensure there is adequate technical support available.	4.00	1.088
Loading speed means average	4.07	
75. Student should be easily downloading the materials from the blog.	4.01	1.077
76. Use hyperlinks to access the files in LMS.	3.95	0.887
Download ability means average	3.98	
77. Ensure that equivalents for dynamic content are updated when the dynamic content changes.	4.14	0.677
78. Provide the ability to refresh the blog.	4.00	0.918
79. Compatible contents for all main browsers (Internet Explorer, Opera, Firefox, Safari and Google Chrome).	**4.87**	0.318
80. Clearly identify the target of each link.	4.34	**0.828**
Browsing means average	4.34	
Accessibility means average	4.16	

The first and most important indicator 79 obtained the highest mean score in the survey of M= 4.87, indicating that compatible content for all main browsers is a critical indicator that may influence the effectiveness and dissemination of the educational blog. Furthermore, download ability indicator 71 obtained (M= 4.39) indicated that the time of uploading blog page is a very important indicator to increase the interaction between students.

4 CONCLUSIONS

The purpose of this paper was identifying educational blogs criteria to improve the student's interaction and communication. According to results the accessibility criteria scored 4.16 out of 5. In the second priority, came navigation category criteria that scored 4.10 indicated that navigation style helps students to achieve their blog objective. followed by category criteria of media use and usability. However, it is surprising thing to note that the amount of importance for learning objective in the literature and research, but was rated low means score of M= 3.54 except, only indicator 56 obtained a mean score M= 4.18 this was the most outstanding that was noted in this study.

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Automated Scenario Generation
Coupling Planning Techniques with Smart Objects

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Abstract: Serious games allow for adaptive and personalised forms of training; the nature and timing of learning activities can be tailored to the trainee's needs and interests. Autonomous game-based training requires for the automatic selection of appropriate exercises for an individual trainee. This paper presents a framework for an automated scenario generation system. The underlying notion is that a learning experience is defined by the objects and agents that inhabit the training environment. Our system uses automated planning to assess the behaviour required to achieve the (personalised) training objective. It then generates a scenario by selecting semantically annotated (or 'smart') objects and by assigning goals to the virtual characters. The resulting situations trigger the trainee to execute the desired behaviour. To test the framework, a prototype has been developed to train the First Aid treatment of burns. Experienced instructors evaluated scenarios written by three types of authors: the prototype, first-aid experts, and laymen. The prototype produced scenarios that were at least as good as laymen scenarios. First-aid experts seemed the best scenario writers, although differences were not significant. It is concluded that combining automated planning, smart objects, and virtual agent behaviour, is a promising approach to automated scenario generation.

1 INTRODUCTION

Serious games have become increasingly popular as educational tools. Advances in graphic and AI techniques have provided us with virtual environments, inhabited by believable characters, where the trainee can practise the learning tasks autonomously. To enhance the effectiveness of these environments, serious games incorporate features from efficacious training forms (e.g. Peirce et al. (2008) and Peeters et al. (2012). A training methodology that, because of its story-like nature, lends itself especially well for this prupose is Scenario-based Training (SBT). SBT primarily concentrates on the type of exercises, i.e. contextualized, whole-task storylines, exemplifying the learning-by-doing approach to training (Oser et al., 1999; Salas et al., 2006). In SBT the trainee is confronted with a representative sequence of events (the scenario) within a simulated environment (e.g. the game). Of course, most training methodologies also recommend a certain ordering of learning tasks (Merrill, 2002). However, the planning and ordering of learning tasks is not the issue in the work presented here.

The problem discussed in this paper is that once such an ordering has been established, suitable exercises need to be created to provide the trainee with practice opportunities regarding the selected learning task. Since manual scenario creation is a time-consuming process, most systems reuse a limited set of scenarios linked to each learning task, however, after several occasions, scenario repetitions becomes inevitable. This is a problem for training directed at skill maintenance, i.e. continued training. Moreover, to ensure effectiveness, the exercises (scenarios) should be adapted to the individual needs and abilities of the trainee, and offer him varied experiences (Peeters et al., 2012). As such, the need for automated scenario generation arises.

In this paper we propose an automated scenario generation framework to produce training scenarios that encompass a previously selected learning objective while warranting complete and coherent storylines. The next section first considers related work on automated scenario generation. Section 3 then details the design, followed by the evaluation in Section 4. Finally, Section 5 discusses the implications of our research and opportunities for future work.

2 RELATED WORK

There is no generally accepted solution to scenario generation, despite it being a growing subject of interest. This section discarusses some existing approaches.

The two works discussed below focus on the creation of a game world that matches the intended learning task. Martin et al. (2009) propose to construct an initial scenario based on the training task, which in turn is extended by adding events to increase the complexity level. The requirements on the game world that follow from the resulting conceptual scenario are addressed using a shape grammar. Lopes and Bidarra (2011a) also focus on the realisation of the scenario within the virtual world, arguing that the contents of the game world determine the trainee's experience. They propose the use of Smart Objects (Kallmann and Thalmann, 1998), which are annotated with the services they offer to their surroundings, such as the experiences they could offer a player. These annotations can be used to steer the content selection process. Although in both of these approaches content generation sprouts from the initial learning objective, the lack of an explicit task representation makes it difficult to interpret the resulting training scenario within the context of the training domain. It is also impossible to derive the expected action plan for the trainee.

In contrast, Niehaus and Riedl (2009) employ automated planning techniques to construct a scenario based on the trainee's expected action sequence. By adapting a default scenario plan, consisting of ordered high level tasks, these action sequences can be adjusted to the needs and abilities of the trainee while maintaining a coherent storyline . An important advantage of this approach is the possibility to track the actions the trainee is required to perform to accomplish the learning task. Moreover, the action sequence has been derived from an explicit representation of the training domain, which promotes the interpretation of the scenario with respect to the learning content.

The next two approaches select events to persuade the trainee into performing the desired actions. Grois et al. (1998) employ probabilistic networks to compute a set of events likely to cause an opportunity for practising the learning task. Zook et al. (2012) use a basic set of events and, subsequently, use a genetic algorithm to extend, mutate and improve the sequence of events until an acceptable scenario has been generated. Both approaches offer interesting alternatives (or additions) yet require very specific data such as probability functions and quantitative scenario evaluation functions, that are all but trivial to define. None of the last three approaches discuss how the scenario should be facilitated by the game world.

3 DESIGN

This section describes the Scenario Generator framework. First, we consider the requirements for effective training scenarios that have driven the design process. Then, the general design is presented, followed by an explanation of the framework's two main components: the Action Planner, and the Object Selector.

3.1 Scenario Requirements

To understand which elements determine the effectiveness of a training scenario we have gathered information from literature studies (Martin et al., 2009; Issenberg et al., 2005; Peeters et al., 2012) and interviews with experienced instructors from different training domains (i.e. First Aid, In-Company Emergency Assistance, and the Dutch Royal Navy). From this research, we concluded that in order to be effective a training scenario must be 1) focused on the learning objective, 2) adapted to the trainee's competency level, 3) representative of real life situations, and 4) complete with respect to high level procedures. The last requirement is illustrated by the following example: a first-aid training exercise should not be restricted to the treatment of the victim, but each exercise should also contain the preceding steps of securing the environment and determining the problem, since real life situations will never encompass merely the treatment of the victim.

3.2 The Scenario Generator

The Scenario Generator has been designed to work within the context of an agent-based Adaptive Educational Game (AEG). Figure 1 depicts the general design of the Scenario Generator within the context of the AEG. The system consists of two main parts: an Action Planner and an Object Selector. The Action Planner uses the learning task provided by the AEG to generate a complete and coherent action plan for the trainee (see Section 3.2.1). The resulting action plan imposes requirements on the game world; e.g. actions may require the presence of objects or coordination with tasks performed by other characters (agents). The Object Selector warrants that such requirements are met by selecting the appropriate objects and agents (see Section 3.2.2).

The Scenario Generator requires the following input from the AEG. 1) The *learning task* encompassing the learning goal that the trainee is supposed to

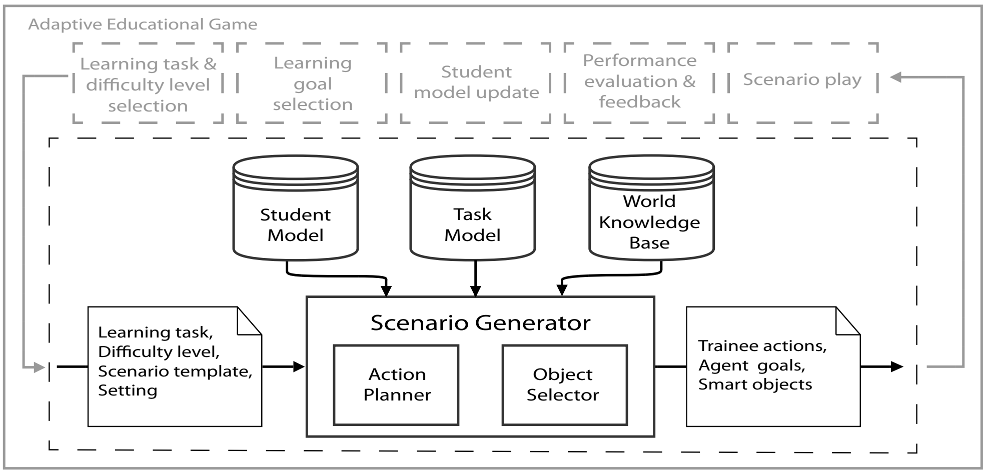

Figure 1: An overview of the Scenario Generator within the Adaptive Educational Game.

practise during the scenario (e.g. ‘treat burn’). 2) The *difficulty level* at which the learning task should be practiced. This level is defined as a value between 0 and 1, representing the skill level required to successfully perform the learning task, where 0 indicates no skill and 1 represents mastery. 3) The *scenario template*: an ordered list of high-level tasks that constitute a complete training exercise. 4) The *setting*, identifying the desired contextual location of the scenario (e.g. ‘the kitchen’). The setting is used to ensure authenticity and influences the object selection process. Additionally, the Scenario Generator is assumed to have access to a student model containing the trainee’s current performance levels, a domain-specific task model containing information about the decomposition of learning tasks, and a world knowledge base describing the available objects and agents along with their domain-specific features.

The output of the Scenario Generator is a *scenario plan* that contains all the information required by the AEG. 1) *Trainee Action Plan*: a partially ordered list of actions the trainee is expected to perform. 2) *Agent Goals*: a list of high-level goals for the virtual agents (e.g. ‘create fire’). 3) *Smart Objects*: a list of the required Smart Objects annotated with parameters that influence the difficulty level at which they offer the required services (i.e. interaction possibilities).

3.2.1 Action Planner

The Action Planner creates a coherent action sequence for the trainee that encompasses the learning task, and constitutes a complete training exercise because of the scenario template used in the process. In addition, the planner determines the goals for the virtual agents (i.e. events) that are expected to trigger this action sequence. Like Niehaus and Riedl (2009), the action planner employs a hybrid HTN plan-space planner. Such a planner employs domain-specific knowledge to decompose abstract high-level tasks into concrete actions meanwhile addressing open preconditions by adding new actions and introducing causal links between existing actions. The domain-specific knowledge used by the HTN planner is stored in the form of so-called *methods*. A method specifies how a high-level task can be decomposed into subtasks (see Ghallab et al. (2004) for a more formal definition). For our particular purpose, we extend the domain knowledge stored in an HTN method with two components: preconditions in the form of services that must be offered by the game world before a method can be applied; and an indicator of the difficulty level of the method. An example of a precondition would be that to decompose the task ‘remove danger’ into ‘extinguish fire’ the service ‘fire’ must first be offered. The difficulty level, a value between 0 and 1, allows the Action Planner to influence the difficulty of the scenario by comparing applicable methods in terms of complexity. For example, decomposing the task ‘treat arm injury’ into ‘clean wound’ and ‘dress wound’ might be less complex than decomposing the same task into ‘clean wound’, ‘dress wound’ and ‘apply splint’. The difficulty level is determined by domain experts. The following paragraphs will continue the description of the action planner by detailing the different steps of the scenario generation process (also depicted in Figure 2).

Incorporate the Learning Task. To ensure a complete training exercise, the scenarios need to contain the learning task and follow the scenario template. Therefore, the planner searches for (sequences of) HTN methods that can be applied to decompose the high-level task(s) from the scenario template into a series of subtasks containing the learning task.

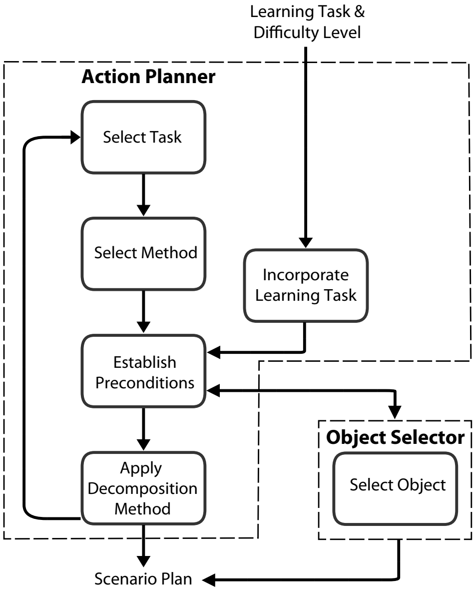

Figure 2: Flowchart depicting the planning process of the Scenario Generator.

Select Task. Once the learning task has been introduced in the planning, the system iteratively addresses the remaining high-level tasks in the scenario template. During this process the system randomly selects the next task to work on in order to promote variety between scenarios with the same input.

Select Method. Each selected task is decomposed into actions by applying decomposition methods. This process is guided by two considerations: the preconditions already established by the game world so far, and the difficulty level of the method. First, the planner selects the methods with the highest number of established preconditions thereby ensuring the coherence of the scenario. If there are multiple candidates, the selection process is guided by the smallest difference between the method's difficulty level and the desired difficulty level. If the task at hand is the learning task, the desired difficulty level is received from the AEG, otherwise the desired difficulty level is retrieved from the student model. Any remaining ties between methods are broken randomly.

Establish Preconditions. Before a method can be applied, all its preconditions (required services) must be fulfilled. The Action Planner forwards the service requests to the Object Selector. Sometimes a service can only be offered after a certain goal has been achieved, e.g. a 'fire' can only be offered after it has been ignited. The Object Selector returns these goals to the Action Planner which plans an action sequence for a virtual agent to achieve this goal. NB: Although the action sequence is not relevant for the output (the virtual agents require goals only), it must be computed since the actions may in turn require new services from the game world.

Apply Decomposition Method. The final step in the process is to actually replace the high-level task with the subtasks specified in the selected method. If these subtasks are actions, the Action Planner also needs to ensure any open preconditions of the actions.

3.2.2 Object Selector

The Object Selector is grants the service requests posed by the Action Planner, by reasoning about the services (i.e. interaction possibilities) the available Smart Objects can offer, such as a match offering the service 'fire'. Agents are considered to be a special kind of Smart Object that can offer more complicated services. In addition, Smart Objects are annotated with preconditions for their offered services, an indication of their belonging in specific settings, and a difficulty level. The preconditions can be other required services, or goals that should be achieved by an agent. The difficulty level is based on three aspects: the complexity of its use, the obviousness of its intended use for the service, and the adaptability of its difficulty level (i.e. a fire can be small and controllable or a raging inferno). The Object Selector determines the most appropriate object based on its belonging in the provided scenario setting and its match to the desired difficulty level. If the selected object requires any other services, the Object Selector iteratively fulfils these requests; if the object requires the achievement of specific goals the Object Selector forwards the request to the Action Planner.

4 EVALUATION

A (proof of concept) implementation of the scenario generator was evaluated, be it with some additional simplifications due to time and resource constraints. The prototype employs a rudimentary HTN planner (not an HTN plan-space planner); all service preconditions are defined as actions (not goals), and there are no ordering constraints on the actions of the agents. These simplifications are of no great concern for the current test setup, though should be addressed in future implementations to fully exploit the advantages of using autonomous agents. The prototype is developed for the training domain of First Aid, which has the advantage that it requires no complex world representations and has clearly defined procedures. To further limit the size of the knowledge base the prototype was restricted to burn-related incidents.

Table 1: Data exploration: mean scores (and standard deviations) over all raters.

Dependent Variable	Scenario Source Expert	Layman	System	Overall
competency suitability	.867 (.448)	-.061 (.431)	.000 (.527)	.269 (.413)
task suitability	1.933 (.290)	.389 (.453)	.800 (.534)	1.041 (.358)
authenticity	1.733 (.210)	.450 (.400)	.583 (.199)	.922 (.167)

4.1 Method

Evaluators - oblivious of the research question - rated scenarios written by the system, human experts and laymen in random order. The scenarios were evaluated on three of the requirements identified in Section 3.1: suitability for the learning task (*task suitability*), suitability for the trainee's competency level (*competency suitability*), and *authenticity*. Completeness of the exercise was omitted, it being too hard to recognize by just the scenario description (the trainee's expected action plan should be included). It was hypothesised that for all dependent variables the experts would score best, followed by the system followed by the laymen. The setup was a within-subjects design; all evaluators rated all scenarios from all sources.

Participants. The experiment used 5 evaluators (all First Aid instructors), and 9 writers (5 First Aid instructors and 4 laymen).

Scenarios. The test set consisted of 36 scenarios: 12 scenarios for each source (experts, laymen, and system). All authors wrote scenarios based on 3 features: 1) the learning task (i.e. treat burn, calm victim, or ensure ABC), 2) the trainee's competency level (i.e. beginner or advanced), and 3) the setting (i.e. home, restaurant, laboratory, or park). Counterbalancing ruled out any possible effects resulting from these features. The authors used a predefined format, consisting of the background story (i.e. what happened), instructions for the 'victim agent', and a list of required objects. The output of the system was not in natural language and was manually rewritten following predefined translation rules.

Questionnaires. Each page of the questionnaire contained a scenario description followed by 3 7-point Likert-scale questions. The *task suitability* and *competency suitability* were measured indirectly; the evaluators rated the suitability of the scenario for a beginner and for an advanced trainee. The highest of the two was used to represent the *task suitability*. The score of the question matching the intended difficulty level was used as a measure of the *competency suitability*.

Procedure. In advance of the experiment proper and after an extensive instruction, inter-rater reliability was fostered by a joint discussion on 2 sets of 6 example scenarios.

Results. Table 1 shows the means and standard deviations of the test set. The results follow the hypothesised trend with the experts scoring highest followed by the system followed by the laymen. The table also shows large standard deviations, in particular for the *system* and *layman* scenarios. The intraclass correlation coefficient (ICC) using the 2-way random model suggested substantial agreement (r=0.732; p<.001). Any missing values (0.01% of the 540 values) were imputed using the SPSS expectation-maximisation procedures (Little and Rubin, 1989). A repeated measures ANOVA revealed significant differences between the sources for *task suitability* ($F(2,8) = 6.699; p = .020$) and *authenticity* ($F(2,8) = 6.220; p = .023$), but not for *competency suitability* ($F(2,8) = 3.529; p = .080$). Post-hoc tests using the Bonferroni correction procedure revealed no significant differences between the sources in one on one comparisons.

Discussion. The experiment revealed no significant differences between the scenarios coming from different sources (i.e. experts, laymen, and system). One possible explanation might have been the large standard deviations, which could have been caused by disagreement among the evaluators, however, the ICC analysis rules out that possibility. Several points for discussion that may shed some light on these results are discussed. First of all, the settings were purposefully varied to show that the prototype is capable of generating scenarios for various situations. However, these settings may have forced the experts to write scenarios for settings they normally would not use. Secondly, the current template does not include the unfolding of the scenario, nor the trainee's expected action sequence, thereby failing to reveal the source's intentions underlying the produced scenarios. The evaluators may have used their experience to interpret the scenario descriptions to infer these aspects, covering up any possible differences. A final point of attention is the importance of involving domain experts in the development of the knowledge base: the task decompositions and the objects used. Even though the used knowledge base contained accurate information, the instructors indicated that it contained some content they would never use in their own scenarios, e.g. electrical burns.

5 DISCUSSION & CONCLUSIONS

This paper addressed the issue of automated scenario generation within the context of an Adaptive Educational Game (AEG). The proposed framework integrates a hybrid HTN planner to plan the trainee's actions with a content selection mechanism based on Smart Objects to control the realisation of the scenario within the game world. This results in a separation of the action plan construction - enabling the retrieval of the scenario's underlying didactic intentions - and the game world creation - enabling the use of a separate smart objects database which is easily extended, in contrast to hard-coded objects in the planner itself. Although the evaluation experiment did not provide significant results, the authors are hopeful that further experimentation will provide more definitive answers.

Several directions for further research can be suggested. First of all, the experiment showed that some of the desired functionalities of the system interfered with its primary goal of producing scenarios with a complexity level that fits the skill level of the trainee. Since the prototype generated complete training exercises, additional tasks were addressed in the scenario on top of the learning task. Because a global difficulty level was used, the trainee is expected to perform the additional tasks at the same difficulty level as the learning task. This combination of multiple tasks seemed too much to handle for the trainee. Two possible (and complimentary) solutions are the integration of a more fine-grained difficulty control system such as for example a performance curve suggested by Zook et al. (2012) and the introduction of 'colleague agents' that take over part of the responsibilities of the trainee. A second suggestion for further research is the comparison of the different approaches proposed for automated scenario generation. So far it has been difficult to compare different approaches since each system uses its own standards and criteria. However, a comparison might be highly informative and show the strengths and weaknesses of the different approaches, possibly leading to hybrid solutions.

To conclude, the framework presented here is a first step towards a system that can generate effective and personalized scenarios automatically. In the future, attaching the system to a game-based training program will offer trainees extensive access to high-quality training opportunities.

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Information Technologies for Supporting in Classroom Learning and e-Learning

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Keywords: Information Technologies, Computer Graphics, e-Learning, Multimedia, Structural Engineering.

Abstract: The paper's main objective is to present a Virtual School (VS), built to provide an infrastructure to develop new methodologies to assist classroom teaching and distance learning in Engineering. The environment of the Virtual School encourages exploration of teaching experiments in search of new pedagogical approaches and methodologies to improve and innovate web-based learning and teaching in the classroom. Based on the experience of graduate students in Information Technology (IT) resources of computer graphics in its broadest definition were used, involving CAD technologies for modeling, animation, text, multimedia and hypertext, photos, pictures and images, which make the visual appeal a powerful tool in improving the teaching-learning relationship. The exploitation of programming languages for the web to build sites, portals and web contents has also been accomplished. One of the most important technological aspects of the Virtual School and of the digital contents is the use of systems management database (DBMS) for the creation, modification, storage and data management. The use of video and sound technologies, videoconferencing and collaboration environments and the construction of a Web platform for e-learning are also part of the goals of this project. Finally, some case studies on web contents based on innovative technologies is presented for distance learning and to assist in classroom teaching of Structural Engineering.

1 INTRODUCTION

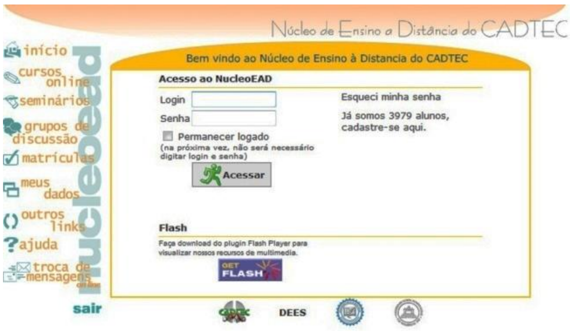
1.1 Development of a Virtual School

The creation of the infrastructure of the Virtual School involves knowledge of programming languages like ASP, ASP.NET, Java, Javascript, C#, ActionScript and mark-up languages such as HTML. Technology CAD for geometrical modeling and animation and graphics programs like Corel Draw, Photoshop and Flash are also important tools to improve the visual appeal of graphic design. Moreover, the management and manipulation of database skills are essential to the development of technologies for web courses.

In addition to these skills, each course taught within the School involves specific knowledge for each content developed such as: AUTOCAD, REVIT, Strength of Materials, Steel Structures, Finite Element Method, among others.

The Virtual School consists basically of an organized structure in the form of an Internet portal that provides computational resources for implementation of multiple activities for teaching and learning specific contents in engineering. These activities consist of seminars and online courses, focused on the areas of Engineering and Computer Graphics. Such activities are being designed to fully exploit the resources of the Internet, and especially those related to the visual appeal of computer graphics (multimedia, animations, videos, photos and images, models, etc. ..), with care to prevent the user is exposed to sensory overload, as recommended by (Torres and Mazzoni, 2004). As pointed out in (Integração, 2012), "*the goal of a customized e-Learning is to create a perfect environment for distance learning through resources like audio, animation and interactivity. In e-Learning, a virtual tutor guides the student through the steps of the course, making sure he interacts with the several access links on the screen. With each* *click, the pedagogical content is presented to the student allowing a dynamic and enjoyable learning*."

Access to the Virtual School-VS (called NucleoEAD) is done via links from the address "*http://www.cadtec.dees.ufmg.br*" of the CADTEC - Center for Advanced Technology Development and Teaching of Computer Graphics. The homepage of the VS is shown in Figure 1.



Bem vindo ao Núcleo de Ensino à Distancia do CADTEC

Acesso ao NucleoEAD

☐ Permanecer logado (na próxima vez, não será necessário digitar login e senha)

Esqueci minha senha

Já somos 3979 alunos, cadastre-se aqui.

Flash

Faça download do plugin Flash Player para visualizar nossos recursos de multimedia.

Figure 1: Virtual School Home Page.

To access some areas of the VS it is necessary to register at the school by providing some personal information and creating login and password. Once registered, access to various spaces and tools of interest is granted.

1.1.1 Technological Features of the Virtual School (VS)

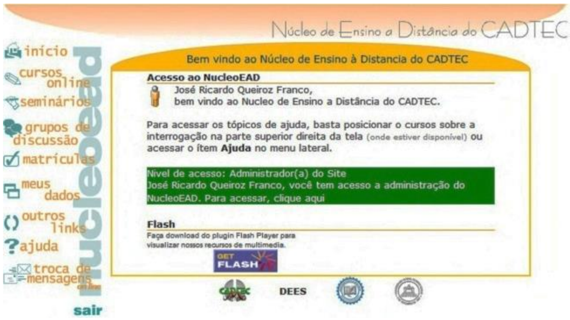
The Virtual School is designed to provide, via the web, the following features shown on the portal of the EV, Figure 1:

- Online Registration (enrollment) to courses;
- Access to Courses Content
- Access to Seminars;
- Discussion forum and news;
- Update of personal information
- Chat Rooms;
- Useful links;
- Help Tool;
- Full control of data through Database.

Tools to establish and facilitate communication between students and lecturers in classroom courses of the Department of Structural Engineering are also available from the Discussion forum link *(grupos de discussao)*. These activities are administered by the lecturer responsible for the discipline. Lecturers and monitors have some limited administrative privileges to control the communication activities.

The Portal of the Virtual School allows students navigate intuitively by the School in an attempt to simulate, as best as possible, the functionality of a conventional school. Thus, students can obtain all information necessary to participate in the activities available.

Figure 2 shows the homepage after someone has accessed the VS. The green band indicates that the person logged in has administrator privileges to access the virtual school.



Bem vindo ao Núcleo de Ensino à Distancia do CADTEC

Acesso ao NucleoEAD

José Ricardo Queiroz Franco,
bem vindo ao Nucleo de Ensino a Distância do CADTEC.

Para acessar os tópicos de ajuda, basta posicionar o cursos sobre a interrogação na parte superior direita da tela (onde estiver disponível) ou acessar o ítem **Ajuda** no menu lateral.

Nivel de acesso: Administrador(a) do Site
José Ricardo Queiroz Franco, você tem acesso a administração do NucleoEAD. Para acessar, clique aqui

Flash

Faça download do plugin Flash Player para visualizar nossos recursos de multimedia.

Figure 2: VS Home Page - Administrator Login.

1.2 Technological Basis Applied *(Software, Programming Languages and Technologies)*

One goal of the Virtual School is to explore technological resources in developing environments for distance learning, more specifically, to the development of tools to aid distance learning in structural engineering via web.

There are many motivations for this development, among which we can highlight the advancement of Information and Communication Technologies (ICTs), the advancement of internet programming languages (OOP) and the opportunities that this type of distance learning via the web offers in the area of engineering, (Neves, 2003).

Software. The main cast of software used are essential in the application of computer graphics environments for distance learning, for example: Microsoft Visio, Dreamweaver, Access, Microsoft Visual Studio framework, Flash, CorelDraw, AutoCAD and Revit.

Technologies and Programming Languages. The UML technology (*Unified Modeling Language*) consists of a language for modeling, specification, documentation, visualization and design of systems, including object-oriented. The UML was adopted in 1997 by the Object Management Group (OMG) as a standard language for software modelling, (Guedes, 2010).

The object oriented programming (OOP)

paradigm has been widely used associated with the following programming languages for the web: C#, ASP/ASP.NET, Java/Javascript and ActionScript. OOP is a paradigm of analysis, design and programming of software systems based on the composition and interaction of various software units called objects.

C# is a simple and complete object-oriented programming language, which is part of the framework .NET. The framewok.NET is a runtime environment and a class library that allows the abstraction of the operating system and of the hardware, (MSDN, 2012). The framewok.NET also encompasses an environment for developing applications for the web called ASP.NET. The main features of ASP.NET are: the choice of various programming languages, allows compilation, and is a component-based model (web controls, HTML controls and user controls), which allows complete separation of code and language HTML, (MSDN, 2012, W3Schools, 2010).

ASP (Active Server Pages) is not a language; it is a program that runs inside IIS (Internet Information Service). An ASP file can contain text and HTML scripting languages (VBScript or JavaScript); scripts in these files are executed on the server side (IIS) and return an HTML page to the browser.

JavaScript is a scripting language (interpreted). It appears as lines of code in the middle of the HTML page.

ActionScript is a scripting language used by Flash. This language uses concepts of object-oriented programming. You can make your pages more "intelligent", with additional features such as displaying the current time, make sure to fill out a form is correct, and more, (JavaScript Tutorial Brasil, 2005).

The technology CSS (*Cascading Style Sheets*) was applied to define styles for the appearance of HTML elements.

HTML (Hypertext Markup Language) is a markup language used to produce static pages for Web publishing. This language was developed for the presentation of data in browsers.

1.2.1 Database

The use of management systems Database (DBMS) for data manipulation of the EV is one of the key technological approaches in this project.

BD Relational Management Systems (DBMS) to facilitate change and data storage and ensure greater security and data integrity and better management control. A DBMS is composed of a control software and the database.

The DBMS used to manage the databases of the Virtual School and Digital Content are the following:

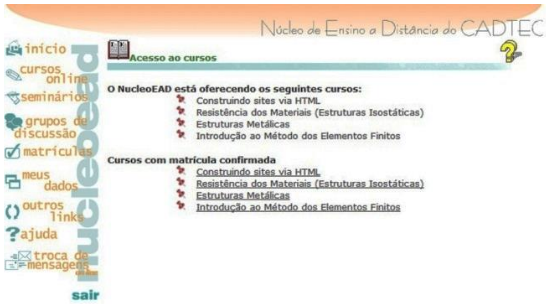
MSDE 2000 - Microsoft SQL Server 2000 Desktop Engine is a free version of SQL Server. It is a relational database server, which can used in smaller applications

Access - RDBMS from Microsoft, designed for small and medium applications, multi-user and multitasking. It is a data file and not a data server.

MySQL - The system is a MySQL relational database, multi-user and multitasking. It is free software and "open source", supports different platforms

2 DEVELOPMENT OF DIGITAL CONTENTS FOR COURSES

Once logged in you can access all areas of VS, including the area where the digital content of the courses are available online. However, to access the digital content of a course it is required to enroll in it. To enroll in a course simply click "Enrolment" (Matriculas) and choose one of the courses shown in Figure 3.



O NucleoEAD está oferecendo os seguintes cursos:
- Construindo sites via HTML
- Resistência dos Materiais (Estruturas Isostáticas)
- Estruturas Metálicas
- Introdução ao Método dos Elementos Finitos

Cursos com matrícula confirmada
- Construindo sites via HTML
- Resistência dos Materiais (Estruturas Isostáticas)
- Estruturas Metálicas
- Introdução ao Método dos Elementos Finitos

Figure 3: Access to Course Content.

The four courses have free access. The structure of the digital content of the courses is basically the same, nevertheless, the graphical designs of the portal and of the digital content of each course are unique, thanks to the creativity of those who developed them. See an example in Figure 4.

2.1 Typical Course Structure

The structure of all digital contents were designed to develop standard functional environments to make navigation easy and intuitive to users. Such a structure can be itemized as follows:

José Ricardo Queiroz Franco, seja bem-vindo(a) ao curso de Estruturas Isostáticas!

Inicie o curso através da Apresentação, onde você encontrará descrições sobre o curso, professores, recursos utilizados e instruções para iniciantes.

Para aproveitar todos os recursos oferecidos neste curso é necessário ter o plug-in "Macromedia Flash" instalado em seu computador. Caso você não esteja visualizando a animação acima clique no link abaixo para fazer o daownload do plug-in:

Figure 4: Structural analysis of statically determined structures.

2.1.1 Functional Structure of a Digital Content of Courses

The digital content for a course is primarily developed following a standard structure design that can be summarized in the following items:

- Presentation
- Agenda
- Book online (Digital Content)
- Discussion forum
- Online Chat
- Transfer (Upload / Download)
- Seminars
- News
- FAQ
- Searching
- Help
- Bibliography
- Log out

The functionality of each item will be presented using as an *example* the structure of the digital content from the course *Structural analysis of statically determined structures*. In comparison with the definition in (E-learning, 2011), "*E-learning includes numerous types of media that deliver text, audio, images, animation, and streaming video, and includes technology applications and processes such as audio or video tape, ... and computer-based learning, ... and web-based learning. E-learning can occur in or out of the classroom. It can be self-paced, asynchronous learning or may be instructor-led, synchronous learning. E-learning is suited to distance learning and flexible learning, but it can also be used in conjunction with face-to-face teaching, in which case the term blended learning is commonly used.*", the description that follows shows that the digital content of the example suits both modes of teaching/learning, "*asynchronous and synchronous learning*"

Figure 4 shows the entrance portal of the course designed in a cheerful and creative format of an amusement park.

The presentation page welcomes the students and briefly describes the technological resources available on the course. In addition, the student receives information about the course objectives, on teachers and on prerequisites. This page contains instructions on how to start the activities and important tips on how to undertake a distance learning course. The toolbar at the top of pages remains fixed on every page, allowing easy navigation through the course content. The link "Agenda" leads to a page where the instructor sets a schedule for completion of the course with targets and timeframes for each activity that the student must follow during the course. The importance of meeting this agenda for distance education courses should be emphasized (Chaves, 1991).

The hyperlink "Apostila" (Book online) allows access to the index of the digital content of the course as shown in Figure 5. A legend shows the technological resources (animation, film, photo, supplementary texts, and exercises) used to enhance the teaching-learning through the visual appeal of computer graphics. This legend also shows icons for downloads, frequently asked questions (FAQ) and for printing.

Apostila Online

Clique sobre o tópico desejado para acessar o conteúdo da apostila.

Legenda

Animação	Filme	Foto	Texto Extra	Exercícios	Download	FAQ	Impressão

Módulo 1 - Conceitos Básicos		
Elementos da Mecânica Estática		Introdução ao conceito de forças
Leis do Movimento - Newton		Aprofundando o conceito de forças
Forças		Apresenta as três leis de Newton
Binários e Momentos		Definição de binário e momento
Cargas		Conceito de cargas concentradas e distribuídas
Equilíbrio de um Sistema de Forças		Conceito de somatório de forças e momentos
Avaliação		Testes do módulo 1
Módulo 2 - Introdução ao Estudo das Estruturas		
Introdução		Introdução ao estudo das estruturas
Estruturas Lineares		Definição de estruturas lineares
Apoios		Definição dos 3 tipos de apoios
Carregamento		Definição dos tipos de carregamento
Graus de Liberdade		Definição dos tipos de graus de liberdade
Tipos de Estruturas		O que são estruturas hiperestáticas, hipostáticas e isostáticas
Formas Criticas		Apresentação das formas críticas das estruturas isostáticas
Esforços		Definição de esforços internos e externos
Avaliação		Testes do módulo 2
Módulo 3 - Cálculo das Reações de Apoio		
Cálculo de Reações de Apoio		Como calcular reações de apoio em uma estrutura isostática
Exercícios Resolvidos	Viga em balanço 1 Viga biapoiada Viga em balanço 2 Pórtico 1 Pórtico 2	Exercícios resolvidos sobre cálculo das reações de apoio
Cálculo das Reações de Apoio em Pórticos e Arcos Triarticulados		Como calcular reações de apoio em pórticos e arcos triarticulados
Exercícios Resolvidos	Pórtico Triarticulado Arco Triarticulado	Exercícios resolvidos sobre cálculo das reações de apoio em estruturas triarticuladas
Avaliação		Testes do módulo 3
Módulo 4- Cálculo dos esforços solicitantes		

Figure 5: Apostila (Book online) (Hyperlinks to the Digital Content).

The Digital Content was divided into four (04) modules:

- Module 1: Basic Concepts

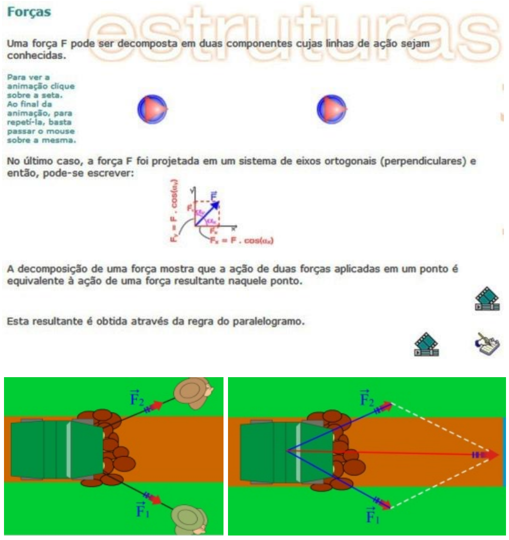
- Module 2: Introduction to Structural Systems
- Module 3: Calculating Support Reactions
- Module 4: Calculation of Normal and shear forces and bending moments and their diagrams

At the end of each module, the student undergoes an evaluation according to some defined criteria.

2.1.2 Module 1: Basic Concepts

The icon "Forcas" (*Forces*) in Figure 6, from the Module 1 lectures on force and its components and resultant force. The theoretical concepts and definitions are illustrated through animations and movies as shown in Figure 6. A list of solved exercises is also available.

To gain access to the next module students must pass an assessment test. Figure 7 shows question 5 of item 3 (Forces) of the assessment test in Module 1.



Forças

Uma força F pode ser decomposta em duas componentes cujas linhas de ação sejam conhecidas.

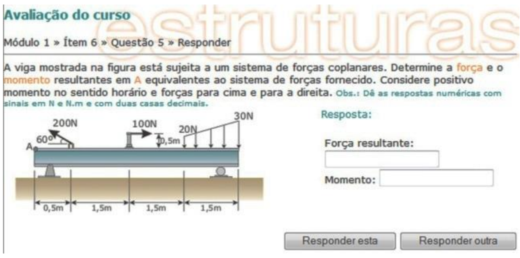
Para ver a animação clique sobre a seta. Ao final da animação, para repetí-la, basta passar o mouse sobre a mesma.

No último caso, a força F foi projetada em um sistema de eixos ortogonais (perpendiculares) e então, pode-se escrever:

A decomposição de uma força mostra que a ação de duas forças aplicadas em um ponto é equivalente à ação de uma força resultante naquele ponto.

Esta resultante é obtida através da regra do paralelogramo.

Figure 6: Forces, components and resultant force.



Avaliação do curso

Módulo 1 » Ítem 6 » Questão 5 » Responder

A viga mostrada na figura está sujeita a um sistema de forças coplanares. Determine a força e o momento resultantes em A equivalentes ao sistema de forças fornecido. Considere positivo momento no sentido horário e forças para cima e para a direita. Obs.: Dê as respostas numéricas com sinais em N e N.m e com duas casas decimais.

Resposta:

Força resultante:

Momento:

Figure 7: Module 1 - Item 6 (Balance of Systems of Forces) - Question 5.

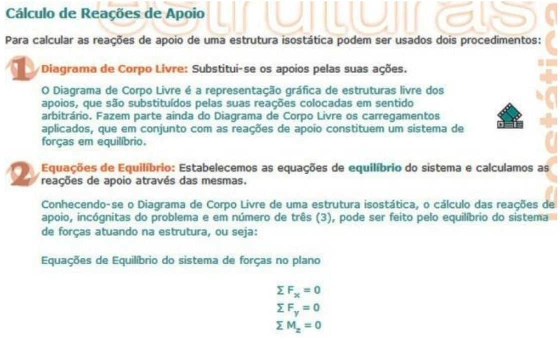
2.1.3 Module 2: Introduction to Structural Systems

Important concepts about structural systems, support systems, load types, degrees of freedom, types of structures, critical forms and types of forces are introduced in Module 2. Photos, (Figure 8), illustrating two types of support, a fixed pin support and a mobile roller support, help the student in understanding these concepts. Again, in the end the student has to undergo an evaluation to access the third module.

Figure 8: Fixed pin support and Mobile roller support.

2.1.4 Module 3: Calculating Support Reactions

Once approved in the evaluation of Module 2 students gain access to the next module, which teaches how to calculate support reactions, (Figure 9). Calculation procedure starts with the design of the Free Body Diagram (FBD), defined by replacing the supports by their reactions, which become the unknowns of a problem of equilibrium of force systems. In the case of statically determined plane structures simply use the equilibrium equations of force systems on the plane to determine such reactions at the supports. Access to module 4 will be granted only after the student passes the assessment test on the content of Module 3.



Cálculo de Reações de Apoio

Para calcular as reações de apoio de uma estrutura isostática podem ser usados dois procedimentos:

1. **Diagrama de Corpo Livre:** Substitui-se os apoios pelas suas ações.

   O Diagrama de Corpo Livre é a representação gráfica de estruturas livre dos apoios, que são substituídos pelas suas reações colocadas em sentido arbitrário. Fazem parte ainda do Diagrama de Corpo Livre os carregamentos aplicados, que em conjunto com as reações de apoio constituem um sistema de forças em equilíbrio.

2. **Equações de Equilíbrio:** Estabelecemos as equações de **equilíbrio** do sistema e calculamos as reações de apoio através das mesmas.

   Conhecendo-se o Diagrama de Corpo Livre de uma estrutura isostática, o cálculo das reações de apoio, incógnitas do problema e em número de três (3), pode ser feito pelo equilíbrio do sistema de forças atuando na estrutura, ou seja:

   Equações de Equilíbrio do sistema de forças no plano

$$\Sigma F_x = 0$$
$$\Sigma F_y = 0$$
$$\Sigma M_z = 0$$

Figure 9: Calculating Support Reactions.

2.1.5 Module 4: Calculating Normal and Shear Forces and Bending Moments and Their Diagrams

On the first page of Module 4 fundamental concepts of internal forces are presented. Then, fundamental exercises on the calculation of internal forces are resolved through animated videos. The sign conventions adopted for the calculation of the internal forces is described and illustrated by images and drawings.

Then the concept of balance of nodes and bars is introduced with the aid of graphic video animations.

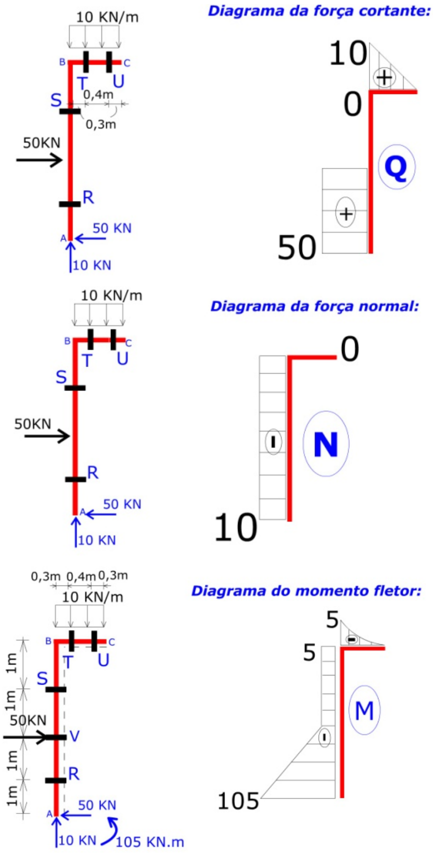
Further, a simple way to derive the equations of internal forces in individual bars is demonstrated also through video animations.

Internal Forces Diagrams (Normal and Shear Forces and Bending Moments)

A brief introduction to internal forces diagrams is made in the introductory page of the issue. On this page access to a video animation is available through the legend to Figure 10.

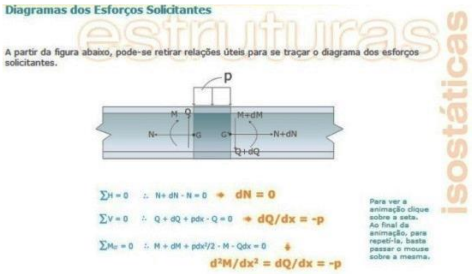
Figure 10: Legend to access video.

The video shows the construction of internal forces diagrams on a cantilever bar subjected to a concentrated load and an uniformly distributed load. The results are shown in Figures 11. The construction of the diagrams using the visual appeal of a video enhance learning and allow the student to rewind the animation in case some concept needs to be reinforced.



Figures 11: Internal Forces Diagrams.

An important auxiliary tool in tracing the diagrams of internal forces are the Auxiliary Differential Equations. These are deducted from the balance on the free body diagram of an infinitesimal element of a bar subjected to a generic distributed load. Differential equations provide various useful information about the format of diagrams, even before they are plotted. The derivation of these equations is presented through animation and the results are shown in Figure 12.



Diagramas dos Esforços Solicitantes

A partir da figura abaixo, pode-se retirar relações úteis para se traçar o diagrama dos esforços solicitantes.

$\sum H = 0 \quad \therefore \; N + dN - N = 0 \rightarrow dN = 0$

$\sum V = 0 \quad \therefore \; Q + dQ + pdx - Q = 0 \rightarrow dQ/dx = -p$

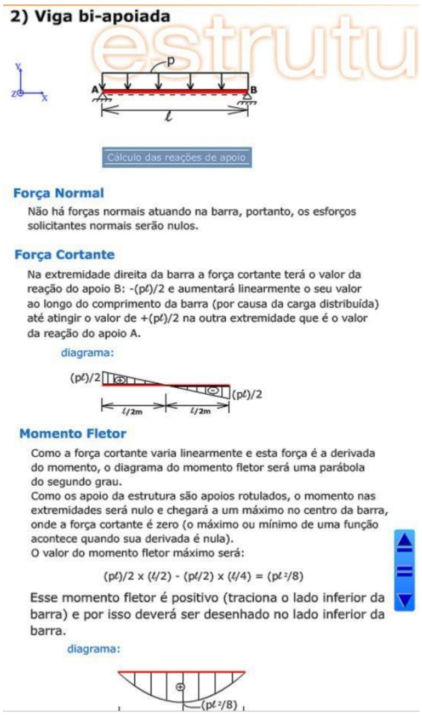
$\sum M_G = 0 \quad \therefore \; M + dM + pdx^2/2 - M - Qdx = 0 \downarrow$

$d^2M/dx^2 = dQ/dx = -p$

Para ver a animação clique sobre a seta. Ao final da animação, para repetí-la, basta passar o mouse sobre a mesma.

Figure 12: Auxiliary Differential Equations for Tracing Internal Forces Diagrams.

In the following pages, examples of the determination of internal forces diagrams in beams are presented through video animations. The diagrams and the solution for a bi-supported beam subjected to a uniformly distributed load are shown statically in Figure 13.



2) Viga bi-apoiada

Força Normal

Não há forças normais atuando na barra, portanto, os esforços solicitantes normais serão nulos.

Força Cortante

Na extremidade direita da barra a força cortante terá o valor da reação do apoio B: -(pℓ)/2 e aumentará linearmente o seu valor ao longo do comprimento da barra (por causa da carga distribuída) até atingir o valor de +(pℓ)/2 na outra extremidade que é o valor da reação do apoio A.

diagrama:

Momento Fletor

Como a força cortante varia linearmente e esta força é a derivada do momento, o diagrama do momento fletor será uma parábola do segundo grau.
Como os apoio da estrutura são apoios rotulados, o momento nas extremidades será nulo e chegará a um máximo no centro da barra, onde a força cortante é zero (o máximo ou mínimo de uma função acontece quando sua derivada é nula).
O valor do momento fletor máximo será:

$$(p\ell)/2 \times (\ell/2) - (p\ell/2) \times (\ell/4) = (p\ell^2/8)$$

Esse momento fletor é positivo (traciona o lado inferior da barra) e por isso deverá ser desenhado no lado inferior da barra.

diagrama:

Figure 13: Internal Forces Diagrams - Bi-supported beam subjected to a uniformly distributed load.

3 CONCLUDING REMARKS

E-Learning has become an essential mode of education for massive dissemination of knowledge. The increasing expectations of society for new methodologies and pedagogical approaches impose great challenges for e-Learning (Shimizu, 2006). Therefore, every project in distance education should be initiated through a careful planning including maintenance and prediction of continuous improvement through technological and methodological projects. The content of a course for e-Learning should be well prepared, taking care not to overload the page with text or multimedia features. This certainly transforms the study into something enjoyable rather than stressful. Texts, audios and interactive tools should be balanced, so that the visual appeal of multimedia serves to reinforce the learning of concepts, making the learning environment natural and intuitive, where the student is challenged to be more active in the learning process. In this process the student learns through digital contents available for free on the web.

The Project of Virtual School presented here required an intense program for qualification and training of the team of developers, which was constituted mostly of graduate and undergraduate students. The qualification program included learning programming languages for the web and practice with modelling in computer graphics. Furthermore, the digital contents developed within the project require specific knowledge for each course. Projects of this type show the importance of a multidisciplinary team, with professionals in education, information technology, communication, arts, and experts in specific content, among others. Further, analysis and definitions of teaching methodologies and developing the educational contents of courses are activities that require professionals in education.

Two aspects of the Virtual School and of the courses digital contents developed in this project must be highlighted. First, the access is free and it is available anywhere, anytime to anyone seeking for education and knowledge. Second, the differential of the proposal is the graphical visual appeal of the School environment and especially of the digital contents of the courses.

ACKNOWLEDGEMENTS

We would like to thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico-CNPq and the Fundação de Amparo à Pesquisa do Estado de MinasGerais, FAPEMIG, for their support to this research project.

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Enhancing Estimation Skills with GeoGebra
Volume Ratios of Essential Solids

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Keywords: Volume Ratios, Estimation Skills, GeoGebra, ICT Support.

Abstract: The first part of this article reports the results of a survey focusing on estimation skills relating to the concept of volume. The survey tested pre-service and in-service math teachers of various nationalities and various school types, and investigated their skills in estimating volume ratios of essential solids (a cylinder, a ball, and a cone). The second part of the article analyzes the mathematical background of cone and ball cases. The third part of the article shows the possibilities of GeoGebra software in creating test materials for similar surveys, and — in accordance with the results of the survey — presents dynamic models designed to enhance estimation skills in volume ratios. The text gives detailed instruction on how to create such kind of GeoGebra materials.

1 INTRODUCTION

Estimation is a process whereby one approximates, through rough calculations, the worth, size, or amount of an object or quantity that is present in a given situation. The approximation, or estimate, is a value that is deemed close enough to the exact value or measurement to answer the question being posed (NCES, 1999). The importance of estimation in the school curriculum was acknowledged for instance in the 1986 yearbook of National Council of Teachers of Mathematics, see (Schoen and Zweng, 1986). The acquiring of estimation skills in schools is said to provide an essential practical means of operating within many mathematical and everyday situations in which precise calculation or measurement are contextually defined as either impossible or unnecessary (Levine, 1982).

This article focuses on estimation skills related to the concept of volume, that means on the measurement-type estimation skills. It is particularly devoted to estimating volume ratios. The issue can be represented by the question

> *"What are the corresponding height and volume ratios of a given solid?"*

Precisely, for a given solid and for a given volume ratio m/n we explore the level to which the solid should be filled with water in order to fill exactly m/n of the solid volume. This level is specified relatively, as a ratio of the height of the solid. We may also study the issue conversely — fill the solid to a given height ratio α, and look for the volume of the filled part expressed as a ratio of the volume of the whole solid.

The issue of volume ratios is not a common part of school mathematics, due to difficult calculations backgrounding the problem. On the other side, volume ratios are an integral part of everyday reality. Together it makes the issue an ideal candidate for engaging estimates.

The first part of this article reports the results of a survey focusing on volume ratios of three essential solids: a cylinder, a ball, and a cone. See Figure 1. The survey tested 80 pre-service and in-service math teachers of various nationalities and various school types, and investigated their skills in estimating volume ratios of these solids.

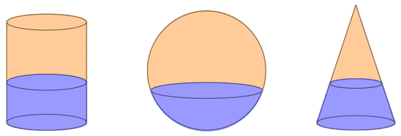


Figure 1: Solids filled with water to a certain level.

The second part of the article analyzes the mathematical background of cone and ball cases.

The third part of the article shows the possibilities of GeoGebra software in creating test materials for similar surveys, and — in accordance with the results of the survey — presents dynamic models designed to enhance estimation skills in volume ratios. The text gives detailed instruction on how to create such kind of GeoGebra materials.

2 THE SURVEY

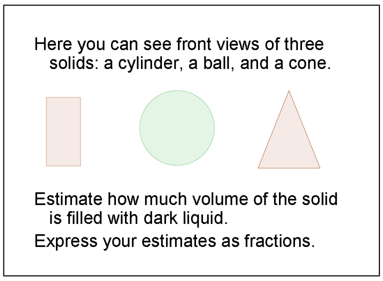
2.1 The Sample

We tested 37 in-service math teachers, namely 11 university teachers and teacher trainers from Czechia, Germany, Serbia and Bulgaria, and 26 teachers from Czech, German and Serbian primary, lower-secondary and upper-secondary schools. These teachers were participants in workshops at some conferences and training seminars held between November 2011 and October 2012.

Concurrently we tested 43 pre-service math teachers from Czech and German universities. These teacher students were not individually selected; the survey was conducted in whole classes.

2.2 The Test

All surveyed teachers got to fill the same worksheet, consisting of 17 quick-answer questions with a common instruction. These questions were open-ended. The worksheet is precisely shown in Figures 2-5.



Here you can see front views of three solids: a cylinder, a ball, and a cone.

Estimate how much volume of the solid is filled with dark liquid.
Express your estimates as fractions.

Figure 2: The worksheet, a title page.

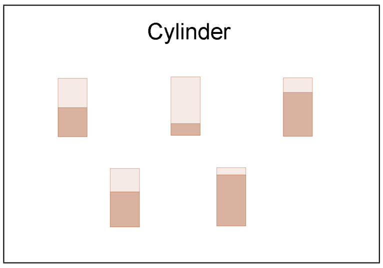


Figure 3: The worksheet, a cylinder page.

The content of the worksheet is of escalating difficulty. It begins with a cylinder case, which serves as a kind of calibration — all volume ratios of a cylinder are identical to height ratios. Then the worksheet continues with a ball, whose height and volume ratios coincide only in $1/2$ case. The final part of the worksheet is devoted to a cone, in which all height ratios differ from their corresponding volume ratios.

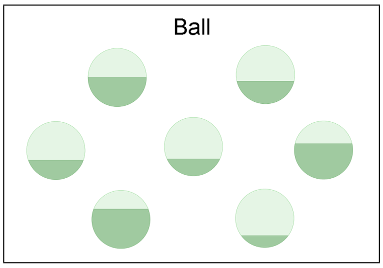


Figure 4: The worksheet, a ball page.

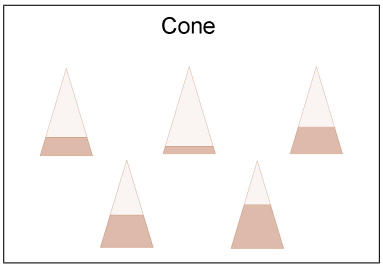


Figure 5: The worksheet, a cone page.

2.3 The Evaluation

We divided respondents into 2 groups according to their status (in-service, pre-service).

We focused on relative errors of estimates calculated as

$$\frac{\text{estimate} - \text{exact answer}}{\text{exact answer}} \tag{1}$$

so that the sign can tell us if the estimate is bigger than the exact answer ($+$ sign) or smaller ($-$ sign).

As the first evaluation method we ascertained relative errors of all outcome estimates, and determined their arithmetic mean and median. A detailed overview can be found in Table 1.

The table shows that both in-service and pre-service teacher respondents have good estimation skills in a cylinder case, and also in a ball case — except 1/10 of the ball volume. Both groups overrated 1/10 of the ball volume, in-service performed a little better, their mean relative error is 44 %. Also both medians are overrated in this case.

On the other side, cone estimates are generally underrated, for all tested volume ratios. The worst cone ratio was 1/2 (with mean relative error -33 %, resp. -32 %), closely followed by 1/4 (with both mean relative errors -29 %).

Since the variability of answers was limited by the requirement to express volume ratios as fractions,

Table 1: Relative errors of in-service and pre-service teachers' estimates; in-service: $N = 37$, pre-service: $N = 43$.

Solid & volume ratio	In-service		Pre-service	
	Mean	Median	Mean	Median
Cylin 1/2	-1 %	0 %	0 %	0 %
Cylin 1/5	-2 %	0 %	0 %	0 %
Cylin 3/4	1 %	0 %	1 %	0 %
Cylin 3/5	3 %	0 %	3 %	0 %
Cylin 7/8	-7 %	0 %	0 %	0 %
Ball 1/2	0 %	0 %	0 %	0 %
Ball 1/3	8 %	0 %	5 %	0 %
Ball 1/4	8 %	0 %	14 %	6 %
Ball 1/5	15 %	0 %	7 %	0 %
Ball 2/3	-2 %	0 %	-1 %	0 %
Ball 3/4	1 %	0 %	-1 %	0 %
Ball 1/10	44 %	34 %	48 %	55 %
Cone 1/2	-33 %	-33 %	-32 %	-33 %
Cone 1/4	-29 %	-20 %	-29 %	-33 %
Cone 2/3	-30 %	-25 %	-28 %	-25 %
Cone 3/4	-19 %	-20 %	-19 %	-20 %
Cone 7/8	-15 %	-14 %	-14 %	-14 %

Table 2: Modus of estimates.

Solid, volume ratio	In-service	Pre-service
Ball 1/10	1/6	1/5
Cone 1/2	1/3	1/3
Cone 1/4	1/5	1/6
Cone 2/3	1/2	1/2
Cone 3/4	3/5, 1/2	3/5
Cone 7/8	3/4	3/4

we may also focus on modus of our data. A detailed overview of cases whose modus differs from the exact answer is in Table 2.

We may also analyze the difference between groups by independent two-sample t-test. Take for example the samples of relative errors belonging to Ball 1/10 picture. Formula

$$\frac{S_X^2}{S_Y^2} = 1,443 \in \left\langle \frac{1}{F_{42,36}(0,025)}, F_{42,36}(0,025) \right\rangle \quad (2)$$

means that we do not reject the hypothesis of equal variances at 0,05 level, and

$$T = 0,399 \leqq t_{78}(0,05) \quad (3)$$

means that we do not reject the hypothesis of equal means at 0,05 level either.

As the last method of evaluation we use the scoring method for Estimation Interview Test used in (Montague and van Garderen, 2003): an estimate is considered accurate if it is within 50 % of the exact answer. From this perspective, the case of 1/10 of the ball volume appears as the one with the highest failure rate: it has 17 inaccurate estimates among in-service teachers' answers (which means 47 % answers being inaccurate), and 23 among pre-service teachers' answers (54 % inaccurate). The second one in terms of failure is the case of 1/4 of the cone volume with 25 %, resp. 28 % inaccurate answers. A detailed overview can be found in Table 3.

Table 3: Percentage of inaccurate estimates.

Solid, volume ratio	In-service	Pre-service
Cylinder 1/2	0 %	0 %
Cylinder 1/5	3 %	0 %
Cylinder 3/4	0 %	0 %
Cylinder 3/5	0 %	2 %
Cylinder 7/8	8 %	2 %
Ball 1/2	0 %	0 %
Ball 1/3	6 %	9 %
Ball 1/4	11 %	23 %
Ball 1/5	11 %	7 %
Ball 2/3	0 %	9 %
Ball 3/4	0 %	7 %
Ball 1/10	47 %	54 %
Cone 1/2	6 %	21 %
Cone 1/4	25 %	28 %
Cone 2/3	6 %	7 %
Cone 3/4	8 %	19 %
Cone 7/8	6 %	9 %

2.4 The Summary

The survey showed that both pre-service and in-service math teachers had significant difficulties with estimating volume ratio from a picture of a cone, and in some cases also from a picture of a ball.

It would be expedient to enhance this kind of estimation skills, for instance through a suitable ICT environment.

3 MATHEMATICAL BACKGROUND

This section shall reveal the mathematical background of the problem of finding the height ratio α for a given volume ratio m/n, and vice versa.

3.1 The Cone

The volume of a cone with base radius r and height k is given by a formula $\frac{1}{3}\pi r^2 k$. The water in the cone reaches an unknown height h, expressed as an α-multiple of the height of the cone, i.e., $h = \alpha \cdot k$.

The complement of the water in the cone is also a cone, with height $k(1-\alpha)$, and base radius $r(1-\alpha)$.

See Figure 6. Thus, the volume of the water can be expressed as

$$\begin{aligned} V_{water} &= \frac{1}{3}\pi r^2 k - \frac{1}{3}\pi r^2 (1-\alpha)^2 k(1-\alpha) \\ &= \frac{1}{3}\pi r^2 k\big(1-(1-\alpha)^3\big) \qquad (4) \end{aligned}$$

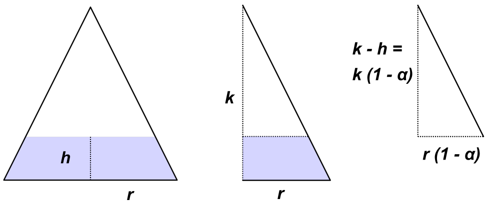


Figure 6: The cone (left), similar triangles (middle, right).

We are looking for a water level corresponding to m/n of the cone volume:

$$\begin{aligned} V_{water} &= \frac{m}{n} \cdot V_{cone} \\ 1-(1-\alpha)^3 &= \frac{m}{n} \qquad (5) \\ \alpha &= 1-\sqrt[3]{1-\frac{m}{n}} \qquad (6) \end{aligned}$$

3.2 The Ball

The volume of a ball with radius r is given by a formula $\frac{4}{3}\pi r^3$. The height of the ball equals $2r$. The water in the ball reaches an unknown height $h = \alpha \cdot 2r$.

The water in the ball occupies a spherical cap with height h, for details see Figure 7.

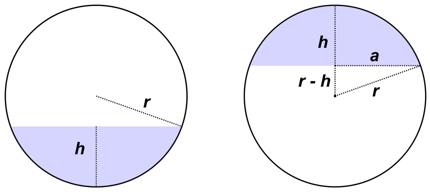


Figure 7: The ball situation in detail.

The volume of the water equals the volume of the spherical cup, that means

$$V_{water} = \frac{1}{6}\pi h(3a^2+h^2) = \frac{4}{3}\pi r^3 \alpha^2(3-2\alpha) \qquad (7)$$

We are looking for a water level corresponding to m/n of the ball volume:

$$\begin{aligned} V_{water} &= \frac{m}{n} \cdot V_{ball} \\ \alpha^2(3-2\alpha) &= \frac{m}{n} \qquad (8) \\ 2\alpha^3 - 3\alpha^2 + \frac{m}{n} &= 0 \qquad (9) \end{aligned}$$

This cubic equation has three real solutions, one of them belonging to an interval $\langle 0,1\rangle$:

$$\alpha = \frac{1}{2} - \cos\left(\frac{\pi + \arccos\left(1-\frac{2m}{n}\right)}{3}\right) \qquad (10)$$

Detailed solution of (9) leading to (10) can be found in (Samkova, 2012).

4 ICT SUPPORT

We shall show the possibilities of enhancing estimation skills with help of ICT, both in passive and active ways. We shall use GeoGebra, free mathematics dynamic software for teaching and learning mathematics at all school levels. GeoGebra is currently available in about 55 languages, it has received several educational software awards in Europe and the USA. For more about GeoGebra see (GeoGebra, 2012).

4.1 Creating Illustrations with GeoGebra

At first we shall demonstrate the passive way of GeoGebra support — dynamic illustrations of transparent hollow essential solids partially filled with water.

4.1.1 The Cylinder

The GeoGebra construction begins with sliders for n, m, cylinder radius r, and cylinder height k. Then we create a front view of the cylinder, which is actually a rectangle with base $2r$ and height k:

```
poly1= Polygon[(r,0),(r,k),(-r,k),(-r,0)]
```

The filled part of the cylinder is also a cylinder, its front view is another rectangle:

```
h=k*m/n
poly2=Polygon[(r,0),(r,h),(-r,h),(-r,0)]
```

The construction is almost done, we just have to design it properly. We change LineThickness of `poly1` to 6, Color of `poly2` to blue, LineThickness of `poly2` to 0, Opacity of `poly2` to 50. The preview of the construction is in Figure 8.

With this dynamic illustration we may prepare various pictures of cylinders filled with water to a certain level, and export them as PNG or EPS files.

We may also export the dynamic worksheet as a webpage, and make it available to students. In this case, we label the r slider with “base radius”, and the k slider with “cylinder height”. We add an interactive text to the worksheet.

The final form of the worksheet is in Figure 9.

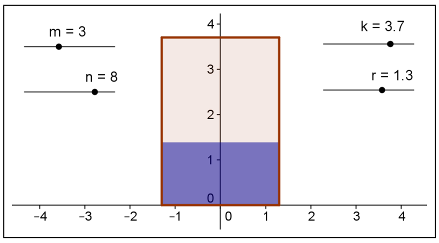
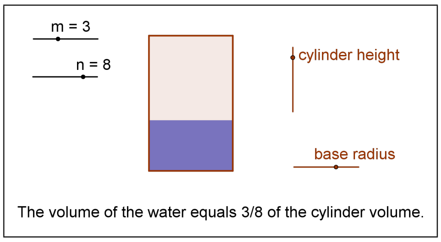


Figure 8: The preview of the cylinder case construction.



The volume of the water equals 3/8 of the cylinder volume.

Figure 9: The dynamic worksheet for a cylinder.

4.1.2 The Cone

The construction begins again with sliders for n, m, base radius r, and cone height k. Then we create a front view of the cone, which is actually an isosceles triangle with base $2r$ and height k:

```
poly1= Polygon[(r,0),(0,k),(-r,0)]
```

The filled part of the cone is a truncated cone, its front view is an isosceles trapezoid:

```
alpha=1-(1-m/n)^(1/3)
h=alpha*k
d=Line[(0,h),xAxis]  ... the water level
Intersect[d,poly1]  ... points A and B
poly2=Polygon[(r,0),B,A,(-r,0)]
```

Now we just have to design the picture the same way as in the cylinder case. The preview of the construction is in Figure 10.

Note that the illustration is not correct for $m = n$. We have to create a blue triangle

```
poly3=Polygon[(r,0),(0,k),(-r,0)]
```

with a Condition to Show Object `m=n`.

4.1.3 The Ball

The construction begins again with sliders for n, m, and ball radius r. Then we create a front view of the ball, which is a circle with radius r:

```
circ1=Circle[(0,r),r]
```

As the next step we solve graphically the equation (9): we define a left side as a function, and find where its graph intersect $\langle 0, 1\rangle$ at the x-axis:

```
f(x)=2x^3-3x^2+m/n
```

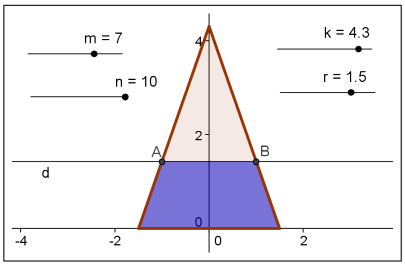


Figure 10: The preview of the cone case construction.

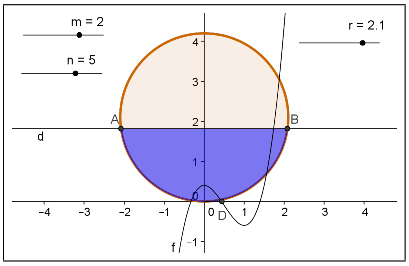


Figure 11: The preview of the ball case construction.

```
a=Segment[(0,0),(1,0)]
D=Intersect[f,a]
alpha=x(D)
```

The filled part of the ball is an upside-down oriented spherical cup, its front view is a circular segment with a chord parallel to x-axis:

```
h=alpha*2r
d=Line[(0,h),xAxis]  ... the water level
Intersect[d,circ1]  ... points A and B
circ2=Arc[circ1,A,B]
```

As previously, we design the picture, and solve separately the situation for $m = n$. The preview of the construction is in Figure 11.

4.2 Interactive Estimation Training with GeoGebra

Now we shall demonstrate the active way of GeoGebra support — a dynamic GeoGebra worksheet for interactive estimation training of volume ratios. This tool focuses on the process of finding the right estimate of water level for a given volume ratio. The worksheet randomly generates volume ratios m/n, waits for the user to draw his estimate to the picture, and evaluates the estimate.

We shall show the construction in a cone case. The construction begins with random sliders for n, m, with sliders for r, k, and with `poly1`, `alpha`, `h` as in 4.1.2. Then we create the exact water level:

```
d=Segment[(-2*r,h),(2*r,h)]
```

This exact answer should be hidden if needed, so that we create a check box `q` with `d` as its selected object, and label it `Exact answer`.

The next step will prepare the picture for user's estimation process:

`p=Segment[(0,0),(0,k)]`

`P=Point[p]`

`o=Line[P,xAxis]`

`Intersect[o,poly1]` ... points A and B

`poly2=Polygon[(r,0),B,A,(-r,0)]`

The preview of the construction is in Figure 12.

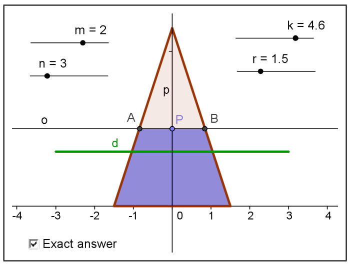


Figure 12: The preview of the training construction.

As a final activity we have to manage the process of generating random values of n, m: we create a button with label `New task`, and with GeoGebra script

`UpdateConstruction[]`

`q=false`

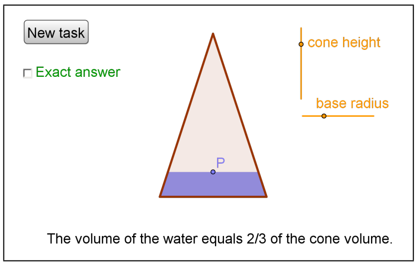
Pressing this button will load new random values for n and m, and hide the segment with exact answer. The user can move point `P` to a position where he thinks the corresponding water level should be, then mark the check box `Exact answer`, and compare his estimate with the line of exact answer.

We may also determine relative error of the estimate: define `err=round((y(P)-h)/h*100)`, and incorporate it into an interactive text with a Condition to Show Object `q=true` to it.

The final form of the worksheet can be seen in Figures 13 and 14.

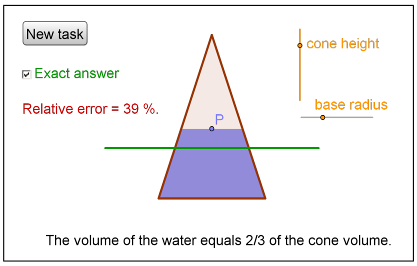
5 CONCLUSIONS

The issue of volume ratios is a remarkable component of the concept of volume. Our survey showed that even math teachers had difficulties with estimating volume ratios of some essential solids. GeoGebra software offers an interesting way how to enhance this kind of estimation skills — through a dynamic GeoGebra environment we can create illustrations related to the volume ratio issue, or an interactive estimation training tool. Future surveys may focus on non-teacher respondents or more deeply on the particular role of GeoGebra in enhancing estimation skills.



The volume of the water equals 2/3 of the cone volume.

Figure 13: The worksheet ready for user's estimation.



Relative error = 39 %.

The volume of the water equals 2/3 of the cone volume.

Figure 14: The evaluation of the user's estimate.

ACKNOWLEDGEMENTS

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Exploratory Study of Effects of Learning System Acceptance on Learning Program Outcomes

Fusing the Technology Acceptance and Technology Mediated Learning Models

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Keywords: Technology Mediated Learning, Unified Theory of Acceptance and Use of Technology.

Abstract: End-user learning is an important element of Information Systems (IS) projects inside organizations. End-user learning can constitute roughly 5% to 50% of project budgets. To lower costs and make learning more convenient for the end-users, organizations are largely utilizing online systems for the electronic delivery of such learning programs, referred to as Technology Mediated Learning. In this scenario, before the end-users are able to immerse themselves in the actual learning program, they are first required to adopt and use an online learning system. Currently published IS research has two mature streams of publications: one stream focused on models of technology acceptance and usage that has lead to the UTAUT (Unified Theory of Acceptance and Use of Technology) model and a second stream focused on the TML (Technology Mediated Learning) framework of learning structures and outcomes. This research study aims to build and validate an empirical model to study of effects of learning system features, content and structure from the TML framework on acceptance and adoption constructs from the UTAUT model and measure how they impact learning outcomes By surveying users of an online learning system and their usage behaviour of specific learning system capabilities, this study measures the acceptance and usage of the system and the learning outcomes of mastering MS-Office productivity software. The results of this study have implications for both the UTAUT and TML research streams and also the design and use of technology mediated learning by practitioners.

1 INTRODUCTION

End-User learning is one of the most pervasive methods for developing human resources within modern organizations to effectively deploy and use Information and Communications Technology (ICT) in their business operations. Majority of learning deals with teaching end-users how to use computer applications and gain skills to do their assigned jobs in the organization. There are three targeted goals of most end-user learning programs (Gupta, et al., 2010): (1) skill-based goals (tool procedural) that target the user's ability to use the system, (2) cognitive goals (tool conceptual or business procedural) that focus on the use of the system to solve business problems and (3) meta-cognitive goals that focus on building the individual's belief regarding their own abilities with the system. To lower costs and make learning more convenient and schedule friendly for employees, modern organizations are currently utilizing online systems for the electronic delivery of end-user learning (ASTD, 2011). Recent reports suggest that upwards of 40-50% of end-user learning is conducted through technology mediated leaning (TML) systems (ASTD, 2011). A comprehensive TML research framework is elaborated in Gupta and Bostrom (2009). In the TML framework, the learning structures (or scaffolds) support the delivery of the learning content, such as the rules, resources and methods, the level of detail in the instructions given to participants, the guidance provided by the facilitator and the nature of the facilities and equipment used in the learning session.

Most commercial TML systems typically are feature rich applications that support various learning tasks and learning scenarios. The set of features allow end users to search learning content, build a customized learning program by planning a sequence of courses, manage their learning progress and even receive a certificate on completion. With the popularity of TML appliations and an increase in cloud based technologies, there is vast diversity in these online learning systems, which employ various platforms and software architectures that pose a variety of challenges (Bensch and Rager, 2012). IS researchers have long called for additional research into the questions of how such technology enhances the learning processes and outcomes (Alavi and Leidner, 2001). Published research has found that the learner's acceptance of e-Learning technologies and specific application features have been found to be important factors that strive to address some of these questions (Lee, Yoon, Lee, 2009; McGill and Klobas, 2009; Piccoli, Ahmed and Ives, 2001).

The UTAUT framework models the factors that govern the acceptance, behavioural expectations and the ultimate usage behaviour of a technological (Venkatesh, Thong and Xu, 2007). It has evolved over 20 years from TAM (Technology Acceptance Model Theory -Davis, 1989) as a vehicle for evaluating factors that impact an individual's acceptance and use of technology. The TAM model conceptualized the relationship between perceived ease of use (the level of difficulty of adopting a technology) and the perceived usefulness of the technology (the user's performance expectations) on the user's intentions to use the technology. Several research studies have applied the Technology Acceptance and Use Model to understand effects of the pedagogical design of such e-learning systems. The focus has been on the impact of learning system features such as learning activities, security, information and service quality, interactivity and responsiveness, learner control and the ability to self-organize their learning on the user's acceptance of those systems (Selim, 2003; Pituch and Lee, 2006; Roca and Gagne, 2008; Sun, et.al., 2008).

Recent TML based research studies about the effectiveness of online learning systems on end user learning task conformance and learning outcomes has been ambivalent (Gupta and Bostrom, 2009). Some have reported positive impacts, while others have not. Such results support the need to merge additional constructs into the TML framework to represent the user's technology acceptance and usage behaviour.

1.1 Research Goals

The focus of this research study is to answer the question "Does the level of acceptance and use of features and capabilities of an online learning system impact learning outcomes?" To answer this question, the paper extends the TML framework with constructs from the UTAUT model and their impacts on learning appropriation and outcomes. The goals of this study are:

- To develop and empirically validate an extended TML research model that also includes the users' learning system usage behaviour and the facilitating conditions supporting such usage.
- To measure the impacts of the usage behaviour and facilitating conditions on the users' learning outcomes.

2 BACKGROUND THEORY

Information technology deployed in typical learning programs is used as a primary structural element in the learning process (e.g. Simulations or exercises that are part of the learning process) or as a secondary tool in the learning process (e.g. Computer based tests and quizzes) The latter approach implies the technology is part of the learning delivery process. However, the actual use of the features and capabilities of an online learning system have been found to differ across groups of users (Bekkering and Hutchison, 2009). Individual differences play a role in what features of these systems are used and how the systems can impact each end-users' learning process and outcome (Gupta, Bostrom and Anson, 2010). The current research stream of IS end-user learning has studied the impact of the above learning structures on different learning outcomes along with various confounding factors such as the individual's learning style, their motivation to participate and their interest in the learning content (Bostrom, et.al., 1990; Nogura and Watson, 2004). While the TML model incorporates technology as a structural element of learning delivery, it does not take into account the usage behaviour of the specific capabilities of the learning platform by the individual users. Individual differences can impact learning outcomes by generating a different mental response to the learning content and influencing their interactions with the learning delivery structures. Learning style of the user plays an important role in the user's conformance to the learning tasks embedded in the online learning system (Bohlen and Ferratt, 1997).

Abstract learners perform better than users with concrete learning styles in online technology based learning. The trainee's motivation and attitudes also

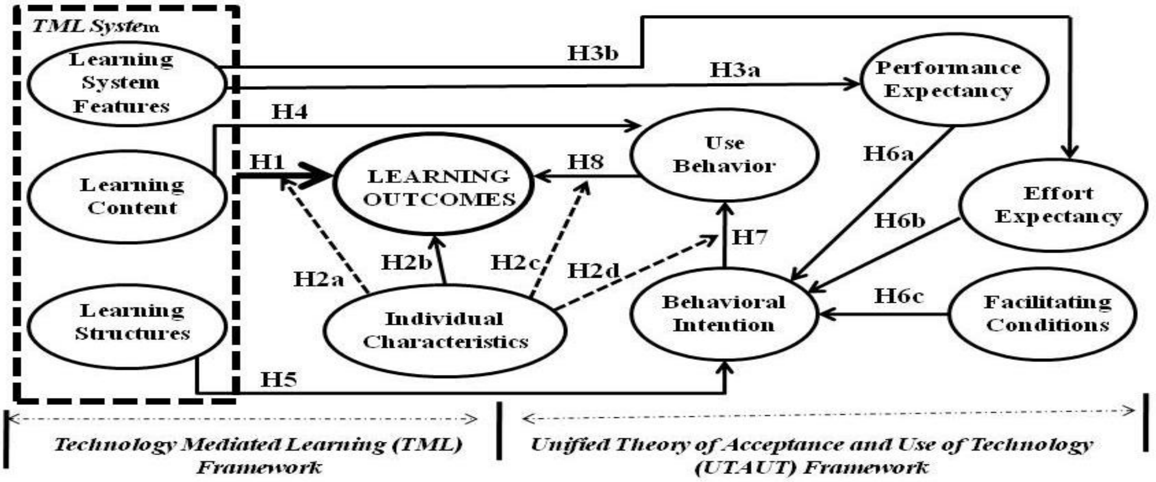

Figure 1: Research Model.

have been found to influence learning performance in the TML context (Szajna, B. and Mackay, J.M., 1995; Yi and Davis, 2003). Both intrinsic motivation and extrinsic motivation played a role in the adoption and appropriation of the learning system capabilities and the completion of the online learning regimen (Gupta, Bostrom and Anson, 2010). Intrinsic motivation has been found to influence the personal innovativeness of the learner that directly impacts how they deal with obstacles faced with the learning system.

The technology acceptance model (TAM) is one of the most widely used models used in Information systems research to study the adoption and usage intensions of individual users towards information systems (Ajzen, 1988; Ajzen, 1991). TAM was developed by Davis (1989) to explain the determinants of the intention to use computer systems. The UTAUT model extended that TAM framework to include facilitating conditions and individual differences that can influence the user's intentions to use a technology (Venkatesh, Thong and Xu, 2012). The UTAUT model also has factors that are related to the working environment in the organization, such as social influence and facilitating conditions. The UTAUT model includes age, gender and experience with technology as important individual differences that moderate intension to use and actual usage behaviour.

3 RESEARCH MODEL

The research model is displayed in Figure 1. The research constructs are defined in the following subsections. The dependent variable in the model is Learning Outcomes (LO).

The independent variables are the three components of the TML system (modelled as a formative second order construct) – (i) Learning system features (LSF), (ii) Learning Content (LC) and (iii) Learning Structures (LS). The Individual characteristics (IC) and Facilitating Conditions (FC) are also independent variables in the model.

3.1 Learning Outcomes

Learning outcomes (LO) focus on the mental awareness and judgements of the end-user and the levels of application of acquired knowledge towards operating business functions (Gupta, et al., 2010). The learning outcomes is a formative construct that consists of three types of outcomes – skill based, cognitive and meta-cognitive.

3.2 Learning Content and Learning Structures

Learning content (LC) refers to instructional methods that encourage students to accomplish learning goals. These allow end-users to fill gaps in their understanding and builds skills (skill focus) and knowledge about how they can use the system to improve their productivity (cognitive focus). "Soft skills" are also developed that allow members to learn collective beliefs and norms that help them develop confidence and knowledge in solving future business problems.

Learning structures (LS) refer to the scaffolds that support the delivery of the learning content. Also referred to as appropriation support (Gupta, et.al, 2010), they include the rules, resources and methods that support the elements of the collaborative learning session. For this research study, the learning structures include level of detail in the instructions given to participants, the guidance provided by the facilitator and the nature of the facilities and equipment used in the learning session.

3.3 Learning System Features (LSF)

As the use of TML in learning programs intensifies, the need to list the features of such applications as a component of the overall learning system is more important. Capabilities mentioned in the research stream refer to responsiveness and quality (Lee, Yoon & Lee, 2009), feedback and facilitation of communications about assigned instructional work (Putuch & Lee, 2006), flexibility, autonomy and user control of the learning process and steps (Piccoli, Ahmad and Ives, 2001).

3.4 Individual Characteristics (IC)

People prefer learning methods based on their specific learning styles (Nogura and Watson, 2004). Individual differences influence the formation of mental models, which effects the learning process. "*States*" are general influences on performance that vary over time and include temporal factors such as motivation level and interest level (Bostrom, et.al., 1990). "*Traits*" are static aspects of information processing affecting a broad range of outcomes. Cognitive traits refer to learning styles such as a preference for procedural or abstract knowledge and an exploratory or reflective approach to instructional content delivery format (Bostrom, et.al., 1990; Nogura and Watson, 2004). For this research study, the Individual characteristics (IC) variable is measured using motivation and interest as states and individual learning style as traits. Both intrinsic motivation and extrinsic motivation influences the learner's state and is measured in the survey.

3.5 Performance Expectancy and Effort Expectancy

Two key components were used in the original TAM model – perceived usefulness an the perceived ease of use of any technology innovation. The UTAUT model includes two components – Performance Expectancy and Effort Expectancy (Venkatesh, Thong and Xu, 2012). Performance Expectancy (PE) is referred to as the "degree to which a person believes that using a particular system will enhance their performance" (in a job or activity). Effort Expectancy (EE) defines the "degree to which a person believes that using a particular system would be free of effort". It is posited that intention to use and actual usage of a system will positively depend on both constructs (Venkatesh, et. al., 2003).

3.6 Facilitating Conditions (FC)

Facilitating conditions are environmental factors that refer to the users' perceptions of resources and support to use the technology (Venkatesh, et. al., 2008). In the context of a learning system, facilitating conditions include resources, accessibility, compatibility with other systems, infrastructure quality and support (McGill and Klobas, 2009; Venkatesh, et.al., 2008).

3.7 Behavioural Intentions and Usage Behaviour

Behavioural intentions (BI) and actual usage behaviour (UB) to use the technology are part of the original TAM and the UTAUT models (Venkatesh, et. al., 2003). Behavioural intentions imply the plans and intentions to use the system. Such intentions can be habit forming and also be constituted from the users' past experiences. Actual usage behaviour refers to the duration, frequency and intensity of the use of the system (Venkatesh, et.al., 2008).

3.8 Research Hypotheses

The research hypotheses are listed below. Given the exploratory nature of this study, the emphasis is to model and test various possible relationships across constructs in the TML and UTAUT models.

H1: The TML System has a positive effect on Learning Outcomes.

H2a: Individual Characteristics will moderate the relationship between the TML System and Learning Outcomes.

H2b: Individual Characteristics will have a positive effect on Learning Outcomes.

H2c: Individual Characteristics will moderate the relationship between Use Behaviour and Learning Outcomes.

H2d: Individual Characteristics will moderate the relationship between Behavioural

Intention and Use Behaviour.

H3a: The Learning System Features will have a positive effect on Performance Expectancy.

H3b: The Learning System Features will have a positive effect on Effort Expectancy.

H4: The Learning Content will have a positive effect on Use Behaviour.

H5: The Learning Structures will have a positive effect on Behavioural Intention.

H6a: Performance Expectancy will have a positive effect on Behavioural Intention.

H6b: Effort Expectancy will have a positive effect on Behavioural Intention.

H6c: Facilitating Conditions will have a positive effect on Behavioural Intention.

H7: Behavioural Intention will have a positive effect on Use Behaviour.

H8: Use Behaviour will have a positive effect on Learning Outcomes.

4 METHODOLOGY

4.1 Data Collection

Our data collection approach will consist of surveying a collection of approximately 400 business school students, who use an online learning system, “MyITLab”, to learn spreadsheet and database software applications. The survey consists of 3 questions for each construct and uses a 5 point Liekert scale (1 being strongly disagree and 5 being strongly agree) to measure user responses to each item. The survey is included in the appendix.

A pilot study has been completed with 45 users and reliability and validity of the survey instruments has been calculated (Table 2).

4.2 “Myitlab” Learning System

MyITLab (www.myitlab.com) is a feature rich learning application that allows users to complete a variety of simulated tutorial exercises and case studies with Microsoft excel and access software packages. While some parts of the system can be cumbersome and requires extensive scaffolding, such as initial registration, login and a properly configured browser for accessibility, yet the major benefits of using the system are quick feedback on assignments, interactive help on various procedural aspects of Excel and Access software and organization of the learning process.

5 PRELIMINARY RESULTS

The 45 surveys collected from the pilot study were analyzed with SPSS version 20 (factor analysis, Scree plot and Cronbach’s alpha) and results are presented in Tables 1 and 2. Factor analysis with Varimax rotation found 6 factors with eigenvalues greater than 0.9 with an explained variance of 78.4%. Four constructs – Learning Outcomes (LO), Learning System Features (LSF), Usage Behaviour (UB) and Individual Characteristics (IC) are formative and do not show as factors. The results also indicate adequate reliability and (Cronbach’s Alphas are above .67 for all constructs) and discriminant validity to proceed with the full data collection during Feb-March 2013. The full survey will be completed and results and hypotheses test outcomes will be presented at the conference.

Table 1: Demographic Variables (n = 45).

Variable	Min	Max	Mean	S.D.
Years of Edu (yr)	2	6	2.96	0.92
Prior Excel Use (yr)	0	8	2.36	1.95
Prior Access Use (yr)	0	6	0.93	1.25
Weekly Usage in Hrs	1	15	3.57	2.66
Gender	Male: 28		Female: 17	

Table 2: Factor Analysis and Construct Reliability (CR).

	PE	LS	FC	BI	EE	LC
Cronbach’s Alpha	**.89**	**.74**	**.72**	**.79**	**.85**	**.67**
Item 1	.81	.32	.74	.66	.37	.66
Item 2	.73	.82	.82	.81	.71	.32
Item 3	.77	.22	.21	.58	.63	.22

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APPENDIX

The Survey Instrument is below:

Excel Usage Experience (in years) ____Years of Education _____
Access Usage Experience (in years) _______ Gender: M F
How many hours/week on average, did you use MyITLab?___
LO1-I understand how I can navigate Excel and Access
LO2-I am confident I can finish an assigned task with office
LO3-I can use features of Excel and Access to solve problems
UB1-I used all of the available features of MyITLab.
UB2-I used MyITLab a lot compared to other learning system
FC1-I had the resources necessary to use MyITLab
FC2-I had the knowledge necessary to use MyITLab.
FC3-I had all the support necessary to use MyITLab
BI1-I had a favourable attitude towards using MyITLab.
BI2-I never disliked using MyITLab
BI3-I am satisfied with the guidance provided by my instructor in the learning process.
LC1-I would use MyITLab to learn another application.
LC2-The learning materials provided me with enough details.
LC3-I am satisfied with the documentation of MyITLab
EE1-It was very easy for me to learn to use MyITLab.
EE2-It was easy to find information about MyITLab
EE3-I found MyITLab to be very easy to use.
LSF1-The output from MYITLab was presented in a useful format.
LSF2-The information from MyITLab is accurate.
LSF3-MyITLab allowed me to take control of my learning process
PE1-Using MyITLab enhanced my effectiveness in learning.
PE2-Using MyITLab increased my productivity in the course
PE3-I found MyITLab to be very useful
LS1-I am satisfied with the facilities and equipment that were available for my use in the learning process.
LS2-MyITLab system fits well with the way I like to learn
LS3-I understood the policies around using MyITLab.
IC1-I was motivated to learn as much as I can from this class.
IC2-I was very interested to take this class.
IC3-I was excited about learning the skills that were covered

Videogames in Education
Comparing Students', Student Teachers' and Master Teachers Opinions and Experiences

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Keywords: Videogames, Education.

Abstract: The purpose of this study was to compare secondary students' experiences and opinions about videogames and their use in education with those of student and experienced master teachers selected by a university to serve as teacher educators. The results of this study demonstrated that a significant majority of secondary school students and student teachers played videogames, compared to a significant majority of experienced master teachers who did not play them. A majority of secondary students and student teachers thought it was a good idea to use videogames to help teach in secondary education, compared to a majority of experienced teachers who did not think this was a good idea. However, a majority of respondents from all three groups thought that videogames could add educational value to the secondary curriculum. There were significant differences for all three participant groups between those who played videogames versus those who did not.

1 INTRODUCTION

Videogames are a common form of entertainment for students in North America. Their participation is often a social experience that happens at home with friends or other players in multiplayer online games like Free Realms™, Halo™, or World of Warcraft ™. These games often require strategic thinking, technical language, and sophisticated problem solving skills (Shaffer, 2006). The levels of player participation, skill mastery, and thought processes required by videogames are attractive to secondary students because they present engaging and challenging virtual experiences which players are able to control and eventually master. The power of videogames to engage young people and hold their attention for long periods of time is a subject of great interest to educators and researchers (Kaufman and Sauvé, 2010). There is a growing sense that videogames are educational; they can teach something (Aldrich, 2005, p.134). Many educators recognize that videogame technologies are highly sophisticated; students are interacting with subject content in ways that differ greatly from established methods of classroom instruction. Some writers even assert that students are exposed to learning processes outside of school that are deeper and richer than the processes they are exposed to in the classroom (Gee, 2005, p.112). Therefore, it appears that videogames can provide constructive, meaningful experiences for students, incorporating educational best practices and learning theories that are relevant in today's world.

However, there is concern in the educational community about the effectiveness of videogames for supporting classroom instruction, how to adapt them into the existing curriculum, the logistics of implementation, and controversy about their possible negative effects.

2 A LEARNING RESOURCE

The ability of videogames to engage and hold the attention of players is well known. They provide the opportunity of learning by doing, by experiencing situations first hand, and through role play (Rickard and Oblinger, 2004, cited in Annetta et al., 2009, p.74). Videogames are user-centered, promoting challenges, co-operation, engagement, and the development of problem solving strategies (Gros, 2007, p.23). Seymour Papert (1994) explained that the best videogames draw children into some very hard learning (Papert, 1994, cited in Prensky, 2001, p.180). Aldrich (2005) stated “people learn better when they don’t know they are learning” (p.34). In designing and producing a commercially successful videogame, game developers create experiences that motivate players, requiring them to use different kinds of problem solving and thinking skills so they can learn to master the game’s content.

Research literature suggests that playing videogames outside of school can help to contextualize content learned in the classroom. Videogames can provide an authentic learning experience for some students by presenting content in a meaningful way that gives them prior knowledge for dealing with academic material at school (Abrams, 2009, p.344). Videogames are a form of alternate literacy practice that is not readily recognized by educators who are required to meet curricular needs (Madill and Sanford, 2007, p.435). They have little experience with videogames and do not see the multiple learning opportunities available to their students. Halverson (2005) argued that participation in game based learning environments can help educators appreciate playing videogames as a legitimate form of learning (p.7).

3 BARRIERS TO VIDEOGAMES IN THE SCHOOLS

The literature demonstrates that there is considerable resistance by educators to using videogames in the schools. Klopfer and Yoon (2005) explained “…videogames and learning have had a tumultuous relationship because many perceive videogames as taking away time from productive learning activities…” (p. 35). An adversarial relationship exists between the cultures of gaming and schooling; school leaders and teachers react negatively to videogames and gaming culture (Halverson, 2005). Videogames are portrayed as a distraction from education that prevents reflection by offering immersive, addictive experiences (Pelletier, 2005). De Freitas (2006) commented: “…there has been a dominant perception of gaming as a leisure pursuit with no pedagogic value…” (p.16). She suggested there were legitimate barriers affecting the use of videogames for learning in schools that included lack of familiarity with game-based software, lack of communities of practice for guidance and support, limited preparation time for learning, lack of access to the required hardware, the cost of software, and the need for necessary technical support (De Freitas, 2006, p.16).

Kirriemuir and MacFarlane (2004) contended that obstacles to using videogames in the classroom include the length of scheduled class periods, verifying a videogame is suitable for learning purposes, the necessary support materials and training required for teachers, and the costs associated with purchasing hardware and software (Kirriemuir and MacFarlane, 2004, p.7). In 2008, the department of Educational Technology at Korea National University surveyed 479 elementary and secondary teachers to determine the factors that inhibited them from using videogames in the classroom. Six significant factors were identified – budget limitations, curricular inflexibility, fixed class schedules, lack of support materials, negative opinions about videogames, and student unreadiness (Baek, 2008, p.669).

The literature shows that the use of videogames in education is a contentious issue. The purpose of this study is to address this issue by comparing secondary students’ experiences and opinions related to videogames and their use in education with those of student teachers and exemplary experienced teachers.

4 RESEARCH METHOD

4.1 Participants

Three unique groups were surveyed at a western Canadian university. The master teacher group consisted of 27 exemplary professional educators selected by SFU to act as mentors. The student teacher group consisted of 45 student teachers training to become professional educators. The secondary student group comprised 85 grade ten, eleven and twelve students from four secondary schools in a suburb of Vancouver, British Columbia, Canada. Participants in each of the three groups were required to give their consent. Anonymity was maintained in this study; the participants were not asked to give their names.

4.2 Procedures

The online survey consisted of five sections that featured a combination of 35 multiple choice and open-ended questions. Section One examined the participants’ level of experience and knowledge of videogames. Section Two asked about their specific experiences with video game hardware and software, frequency of play, with whom the participant played videogames, and experiences of playing videogames at school. Section Three examined the participants' opinions about controversial issues concerning videogames. Section Four examined participants' opinions about videogames and their use in education. Section Five provided open-ended questions that asked about participants' experience with videogames and opinions about using them for educational purposes.

The researchers recruited the respondents personally through class visits and meetings, and participants then completed the surveys during a two-week period. Master teacher and student teacher survey participants were provided with a unique URL web address hosted by Fluid Surveys (http://www.fluidsurveys.com), a Canadian web-based online survey system. Secondary student participants were provided with a unique URL web address hosted on the SFU Web Survey site (http://websurvey.sfu.ca). They completed the survey at computer laboratories in their respective secondary schools. Two classes of secondary students completed hardcopy versions of the online survey that were provided by their teachers.

The data analysis consisted of using PASW (SPSS ver18) to conduct descriptive and inferential data analyses. The three groups were compared on several key items; then an independent samples t-test was used to compare videogame players versus non-players about their opinion regarding the use of videogames in education.

5 FINDINGS

5.1 Videogame Playing Patterns

A majority of secondary students and student teachers reported that they played videogames, compared to a majority of master teachers who said that they did not play videogames. These figures are significant when compared to the age distribution for each participant group. 97% percent of the secondary students were between the ages of 14 and 24 years. 90.5% of the student teachers were between the ages of 18 and 34 years. 96% of the master teachers were older than 35 years, and 48% of them were over 45 years. The results suggest that the majority of young adult participants (under 35 years) play videogames and a majority of participants over 35 years do not play videogames.

5.2 Opinions about Playing Videogames

Almost a quarter of secondary students reported that playing videogames was their favorite kind of entertainment (22.1%) and almost half (43.0%) felt that videogames were just as much fun as other forms of entertainment. More than half of student teachers reported that videogames were fun but that they preferred other forms of entertainment (55.6%). However, more than half of the master teachers did not think videogames were fun and preferred other forms of entertainment (51.5%). The results show that there is a significant difference of opinion between secondary students and master teachers about the entertainment value of videogames.

5.3 Using Videogames to Help Teach

Almost half of secondary school students (47.7%) and a great majority of student teachers (77.3%) think that using videogames to help teach in secondary education is a good or a great idea. More than half of the master teachers (53.6%) think that using videogames to help teach in secondary education is not a good idea or is a terrible idea.

5.4 Educational Value in Secondary School

Table 1: Educational Value of Videogames.

Educational value added	Secondary students		Student teachers		Master teachers	
	N	%	N	%	N	%
Much	21	27.3	2	4.5	0	0.0
Some	38	44.2	24	54.5	15	53.6
Little	18	23.4	16	36.4	8	28.6
None	0	0.0	2	4.5	5	17.9

A majority of secondary students (71.5%) and student teachers (59.0%) think that there is educational value in using videogames in the secondary school curriculum. An interesting fact here is that the master teachers were almost evenly split in their opinion on this question; 53.6% thought that videogames add educational value, while 46.5% did not. Another question in the survey asked secondary students what their teachers would think about using videogames in the classroom. 58% os secondary students said their teachers would think this was a good idea; however, 71% of master teachers said they thought it was not a good idea.

The secondary students' responses were much too optimistic.

5.5 Comparison of Non-Player Vs. Player Opinions

Table 2: Comparison of Non-Player vs. Player Opinions about using Videogames in the Classroom.

Respondent	N	Mean* (SD)	t	p
All respondents				
-Non-videogame player	45	2.80 (1.39)	3.83	.000***
-Videogame player		3.81 (1.45)		
Secondary school students				
-Non-videogame player	6	1.17 (0.41)	9.84	.000***
Videogame player	55	3.87 (1.66)		
Student teachers				
Non-videogame player	18	3.72 (1.18)	.297	.768
Videogame player		3.62 (1.17)		
Master teachers				
Non-videogame player	21	2.48 (1.17)	3.09	.005**
Videogame player	7	4.00 (1.00)		

*Based on a five-point Likert scale
** Significant at the .01 level
*** Significant at the .001 level

Respondents who played videogames were significantly more positive than those who did not play about the idea of using videogames in the classroom. However, there were no differences observed in the student teacher group between videogame players and non-players as both groups responded quite positively about using videogames in the classroom.

6 DISCUSSION AND CONCLUSIONS

The results of this study strongly suggest that professional educators do not have the same level of experience or knowledge about videogames compared to secondary students and student teachers. Because experienced teachers do not play videogames, they are not aware of the broad range of game software experiences their students have outside of school, particularly the level of social networking that now takes place with multiplayer online games played through physical or wireless internet connections. The results demonstrate that there is an 'electronic entertainment generation gap' between professional teachers, secondary students, and student teachers. Master teachers are in positions of educational leadership in their school districts, yet the survey results point to a significant lack of understanding about this influential form of entertainment technology in which students actively participate outside of school.

The survey results also showed that the student teachers are more open to the idea of using them for educational purposes than the master teachers. As they assume positions of leadership in a school or district, this group might contribute to a greater acceptance among educators of using videogames to supplement instruction.

There are educators today who believe that videogames can motivate students who do not respond to traditional methods of instruction. Kurt Squire (2005) considered this fact when he wrote his case study about teaching history with Civilization III^{TM} (Squire, 2005). A few educational institutions and individual educators continue to take the initiative and use videogames for teaching educational content. However, the educational research literature and the results of this study demonstrate that a significant gap exists between experienced educators versus secondary school students and student teachers about their experience and opinions related to videogame technology. Students are enthusiastic adopters of technology, but they do not necessarily possess expert knowledge about how to use it wisely. Educators with limited videogame experience do not understand the technology's potential for classroom instruction. Given the levels of challenge, creative quality, engagement, and immersion contained in modern videogames, educational administrators and policymakers need to work with educators to better understand the influence and scope of this form of electronic entertainment. Current cohorts of student teachers need more training about how to help students and their parents deal with the growing influence of these new technologies and how to incorporate them effectively as a useful addition to their curricula.

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A Pedagogical-based Learning Object System to Support Self-regulated Learning

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Abstract: Self-regulated learning has become an important construct in education research in the last few years. Self-regulated learning in its simple form is the learner's ability to monitor and control the learning process. There is increasing research in the literature on how to support students to become more self-regulated learners. However, advancements in information technology have led to paradigm changes in the design and development of educational content. The concept of learning object instructional technology has emerged as a result of this shift in educational technology paradigms. This paper presents the results of a study that investigated the potential educational effectiveness of a pedagogical-based learning object system to assist computer science students. A prototype learning object system was developed based on the contemporary research on self-regulated learning. The system was educationally evaluated in a quasi-experimental study over two semesters in a core course on programming languages concepts. The evaluation revealed that a learning object system that takes into consideration contemporary research on self-regulated learning can be an effective learning environment to support computer science education.

1 INTRODUCTION

The aim of any instructional approach is to provide students with high-quality learning material and educational tools. In the last few years, the concept of self-regulated learning has received increasing attention in educational research, especially higher education research, because of its importance for academic success and lifelong learning (Dettori and Persico, 2008). Self-regulated learning (SRL) focuses on the learner as central in the learning process and on the explicit use of a variety of learning strategies. It is therefore reasonable to gain a greater understanding of the learner, as a precursor to best integrating aspects of self-regulated learning in the teaching and learning process. We argue that the traditional vision of designing and delivering learning material must be altered to place greater emphasis on students' preferences and needs and increase students' control and monitoring of their self-regulated learning.

In accordance with the advancement of educational technology, the current trend in the instructional design of learning material is the use of digital educational resources that have pedagogical objectives as learning objects (Sosteric and Hesemeier, 2002). Learning objects are distributed via online digital libraries known as learning object repositories. There is an increasing effort to develop standards and specifications for these learning objects, but most of this effort focuses on technical development and ignore pedagogy or educational theories, particularly learning styles and self-regulated learning.

Learning objects can improve the teaching and learning of many disciplines. In particular, computer science education has been criticised for a lack of reference to pedagogical theories. The teaching and learning of computer science concepts are challenging tasks for both teachers and students (Ben-Ari, 1998). This has been reflected in the low level of retention and success among computer science students (Biggers et al., 2008). Today, computer science students have diverse backgrounds, experiences and preferences. Computer science involves studying dynamic and abstract concepts that are difficult for students to understand using traditional teaching and learning methods. Computer science is a rapidly changing area that is driven by new technologies rather than pedagogy (Holmboe et al., 2001). Self-regulated learning behaviour is typical of computer science students because they must learn different concepts in a very short time to keep abreast of the dynamic changes in the field (Rodriguez-Cerezo et al., 2011).

This paper addresses the challenges associated with the design and use of learning objects to improve the teaching and learning of computer science. A pedagogical framework is proposed to improve the design and use of learning objects based on the concept of self-regulated learning and students' learning styles. The framework is then used to develop and evaluate an online learning object system for a core course on programming languages.

2 SELF-REGULATED LEARNING

Self-regulated learning educational paradigms focus on the role of the learner in the learning process, and view the teacher as facilitative rather than dominant over the learning process. Self-regulated learners are active participants in the learning process who utilise metacognitive, motivational and behavioural strategies (Zimmerman, 1990). Metacognition refers to the awareness and control of the cognition process and includes processes, such as goal setting, planning and self-evaluation to control and monitor the learning process (Pintrich, 2004).

Although various models have been developed to illustrate the process of self-regulated learning, they are all based on Zimmerman's Cyclical Model of Self-Regulated Learning (Zimmerman, 2000). Zimmerman's model views self-regulated learning as an integration process between personal, behavioural and environmental processes. According to this model, self-regulated learning occurs via three cyclical phases: forethought, performance control, and self-reflection (Zimmerman, 2000). These phases are cyclical; feedback from the previous phases is used to adjust the next phase.

The forethought phase involves processes that occur prior to learning, including goal setting and strategic planning. Goal setting is the process of determining the outcomes of the learning task. Strategic planning involves the selection of strategies that are suitable for performing the task. The activation of previous knowledge that is required to accomplish the learning task is essential in this phase.

The performance phase involves processes that occur during learning, such as self-control and self-observation. Self-control involves actual learning strategies that students use to manage the learning material (e.g., reading, note-taking, critical thinking, help-seeking, etc.). Self-observation involves metacognitive monitoring strategies that students may use to track and evaluate their progress, such as self-recording and self-questioning. Students employ the technique of self-recording to record each learning activity and its results. They utilise the strategy of self-questioning or testing to assess their understanding of the learning material by performing a test to evaluate performance against a predefined goal or standard.

Self-reflection involves processes that follow learning, such as self-judgment and self-reaction. These processes are closely associated with self-observation. Self-judgment involves two sub-processes, self-evaluation and causal attributions. Self-evaluation is the comparison of individual performance against predefined goals. It also involves comparisons with the performance of other students in the same class. The result of self-evaluation is linked to the causal attribution to determine the cause of this result. For example, a student's poor performance can be attributed to bad strategy selection, insufficient effort, or limited abilities. Self-judgment is linked to self-reaction. Self-reaction involves two sub-processes, self-satisfaction and adaptive inferences. Self-satisfaction is the learner's perception about his/her performance, i.e., whether the learner is satisfied or disappointed. Based on this perception, the learner employs adaptive inferences to determine how to change the self-regulated learning process to achieve a better result. Adaptive inferences involve changing the goals defined in the forethought phase, or choosing other strategies to perform the task.

3 LEARNING STYLES

Learning is the process whereby individuals acquire new knowledge. Research indicates that students tend to gather and process information in different ways. These differences are known as learning styles. Many definitions of the term 'learning style' can be found in the literature. Keefe (Keefe, 1988) defines learning style as the characteristic cognitive, affective and psychological behaviors that serve as relativity stable indicators of how learners perceive, interact with and respond to the learning environment. This is one of the most comprehensive definitions of the learning style, and is adopted by the National Association of Secondary School Principals.

3.1 Summary of Research on Learning Styles

Education researchers agree there are different learning styles that must be accommodated to improve the teaching and learning process. In addition, empirical studies on the implications of different learning styles for students' performance have found significant differences in the levels of academic achievement of students with different learning style (Akdemir and Koszalka, 2008). One explanation for this result is that the learning materials favour specific learning styles and ignore other styles.

There is current debate on how to integrate learning styles into curriculum design and teaching and learning activities. Lack of empirical studies that evaluate the effectiveness of learning styles-based interventions has made it difficult to generate recommendations for teachers and curriculum designers. The research on learning styles focuses primarily on identification of students' learning styles, and how this might affect their academic achievements. In addition, research on learning styles follows a track that differs from that of other educational theories. The role of learning styles in self-regulated learning has not been investigated and appears to offer a potential direction for future research.

The main hypothesis that dominates research on learning styles is called the matching hypothesis (Coffield et al., 2004). This hypothesis argues that if a learner is presented with learning material that is compatible with his/her own learning style, his/her learning process improves. Further, teaching methods that are mismatched with the learner's style might lead to difficulties in learning. However, research on how this hypothesis could be applied in context to improve the teaching and learning process in many disciplines, including computer science, is scarce. Learning style awareness was proposed in response to critical reviews of learning style theories as an alternative and promising hypothesis for future research on learning styles (Coffield, 2004). This hypothesis claims that knowledge of learning styles should be used to increase self-awareness, which leads to improvements in the learning and teaching process. Learners who become aware of their learning styles are more likely to be aware of their strengths and weaknesses and, therefore, have greater control of their learning processes. In addition, teachers who are aware of the diversity of learning styles amongst their students are most likely to adopt teaching approaches that appeal to different types of students. In this case, knowledge about learning styles is used to enhance metacognition, which is an important component in any self-regulated learning model.

3.2 Felder-Silverman Learning Style Model

Learning styles can be identified using different learning style models. There are many learning style models proposed in the literature. The FelderSilverman Learning Style Model (Felder and Silverman, 1988) is a well-known learning style model that is heavily used to identify students' learning styles in many disciplines, especially in science and engineering education. The Felder Silverman Learning Style Model has been adopted in this study as the basis for identifying students' learning styles due to many reasons, some of them are the following:

- It covers more than one level of learning style, thus provides categorisation of students' learning styles based on multiple dimensions.
- It has been used to investigate the learning styles of engineering students, groups of learners similar to the target population of this study (e.g., (Felder and Brent, 2005)) .
- The instrument used by this model is reported to have satisfactory level of reliability (Felder and Spurlin, 2005).

The Index of Learning Styles (ILS) is the instrument that is used to identify learning styles based on this model. This model consists of four dimensions (Felder and Silverman, 1988):

Perception (Sensing/Intuitive): this dimension describes the type of information an individual preferentially perceives. Sensing learners prefer concrete contents and facts, and are detail-oriented, whereas intuitive learners prefer abstract concepts, theories, and mathematical formulas, and dislike details. Sensing learners tend to solve problems using well-established methods, and dislike complications. Intuitive learners like innovations, new ideas of solving problems, and dislike repetition.

Input (Visual/Verbal): this dimension describes the type of presentation an individual prefers. Visual learners prefer learning through visual media, such as pictures, charts, and diagrams, whereas verbal learners prefer spoken or written materials and explanations. Both types of learners learn better when the material is delivered using visual, verbal, and written forms.

Processing (Active/Reflective): this dimension describes how the learner processes information. Active learners prefer learning in groups, and they tend to try things out, whereas reflective learners prefer working alone, and tend to think about how things work before attempting them.

Understanding (Sequential/Global): this dimension describes how the learner progresses towards understanding information. Sequential learners prefer following a logical, step by step linear approach, whereas global learners prefer absorbing the learning materials randomly, in large jumps, without following a step by step approach, until they grasp the full picture. Global learners need to grasp the full picture before going into the details. Courses are normally taught according to a sequential presentation format. Sequential learners can learn effectively under this method of instruction.

4 LEARNING OBJECT SYSTEMS

Advances in information technology have led to a paradigm shift in the way that people communicate and learn. Consequently, the development and delivery of learning materials are changing. To reflect this paradigm shift, a new instructional technology called learning objects emerged as a next generation technique for instructional design, due to its capacity for reusability, adaptability and scalability (Hodgins, 2002).

Increased interest in the concept of learning objects has led to a number of definitions and terms to describe the idea behind learning objects. Sosteric and Hesemeier(Sosteric and Hesemeier, 2002) synthesised several definitions and defined a learning object as "a digital file (image, movie, etc.) intended to be used for pedagogical purposes". A learning object can be published through a variety of methods. The most formal method of publishing learning objects is through learning object systems. A learning object system is any online platform or environment that is used to facilitate authoring, indexing, distributing, and delivering of learning objects (Ritzhaupt, 2010). A learning object system uses a database in which learning objects are stored along with their metadata to be shared. These databases are usually knows as learning object repositories.

Learning objects can support students in their self-regulated learning of, for example, computer science if pedagogical foundations are considered during the design and delivery of these learning objects. There is a paucity of underlying theory that guides the design and use of learning objects (Wiley, 2000). Moreover, the delivery of learning objects in online learning object systems does not follow a predefined pedagogical model based on the latest research in self-regulated learning (Alharbi et al., 2011a).

5 PEDAGOGICAL-BASED LEARNING OBJECT SYSTEM

Education research on learning styles, and that on self-regulated learning, appears to be isolated from one another. Self-regulated learning models that consider the diversity of students' learning styles have the potential to provide a comprehensive understanding of the learning process (Cassidy, 2011). This leads us to return to the metacognitive component of self-regulated learning, which concerns the importance of the learner's awareness and ability to control his/her cognition process. According to this component, learning styles can be used to improve the metacognitive process, which in turn enhances students' motivation and learning. In this way, the future research on self-regulated learning and learning styles can interact to provide a basis for empirical studies that can produce pedagogical recommendations for teachers and instructional designers.

This study presented in this paper synthesises contemporary educational research to provide a greater understanding of the theory of learning styles by placing it in the context of self-regulated learning models. The result of this synthesis is a pedagogical self-regulated learning framework with learning style as one of its main components (Alharbi et al., 2011b). This framework can be used as the basis for improving learning and teaching in many disciplines. However, in the current research, the framework is applied to improve the design of learning object instructional technology in computer science education.

5.1 System Components

Based on the proposed pedagogical framework, the current study develops and evaluates a learning object system with self-regulated learning support. Figure 1 shows the main components of the proposed learning object system.

5.1.1 Learning Object Repository

The learning object repository is responsible for storing different learning objects that are designed to support students in learning about programming languages concepts. This repository stores all learning objects along with their optional XML files that describe the structure of learning objects, and define the animation inside the learning object. All the learning objects are stored in the repository and tagged with relevant metadata to make it easy for students to find them.

5.1.2 Learning Style Awareness Module

The objective of this module is to increase students' awareness of their learning styles and their use of self-regulated learning strategies. This module consists of an initial assessment of students' use of self-

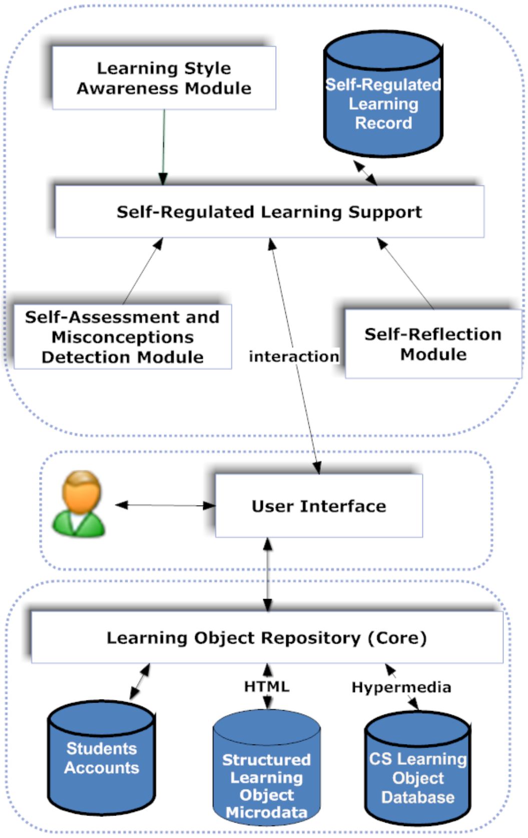

Figure 1: Learning Object System Components

regulated learning strategies and the identification of students' learning styles. A research instrument is used to measure students' self-regulated learning strategies. The learning strategies are categorised based on the research on self-regulated learning. The Index of Learning Styles (ILS) is used in this module to identify students' preferred learning styles based on Felder-Silverman learning style model (Section 3.2) This model describes the learner's preferences based on four dimensions, Sensing-Intuitive, Visual-Verbal, Active-Reflective and Sequential-Global. Upon first login to the system, the student is redirected to complete the learning style assessment. After completing the assessment, the module evaluates the responses and determines the student's preferred learning style. The module increases students' awareness by providing the result, together with a description and recommended learning strategies. Although students are permitted to access all learning objects in the system, the recommended learning strategies consider the strengths and weaknesses of students' preferred learning styles.

5.1.3 Self-assessment and Misconceptions Detection Module

This module is responsible for generating self-assessment questions that help students detect their misconceptions related to the programming languages concepts. These self-assessments are associated with the learning objects that are designed to help students overcome these misconceptions. This module is also responsible for recording each student's self-assessment results in the self-regulated learning record. Each assessment exercise is linked to a specific misconception about programming languages concepts. Learners are given instant feedback after completing each assessment.

5.1.4 Self-reflection Module

Meta-cognition is the most important self-regulated learning process that requires greater attention in online educational environments. This module extracts information from the analysis of students' behaviours, which is stored in the self-regulated learning record, and uses this information to help students develop self-reflection skills. To detect a specific misconception, a number of questions are developed and integrated into the self-assessment. The self-reflection support module extracts information from the results of self-assessments that are stored in the self-regulated learning record, and uses them to calculate the degree of misconception related to a specific concept. In addition, when a misconception is listed in the student's self-regulated learning record interface, the module shows information on the proportion of students with this misconception. This information is shown to the leaner to encourage him/her to overcome these misconceptions. The learner can view additional information on the possible reasons behind these misconceptions, and how to overcome them by considering his/her learning styles. The module also allows a student to view detailed information on his/her behaviour inside the system, including the time spent on each learning object compared to the time spent by other students, and the results of the self-assessment exercises.

5.1.5 Self-regulated Learning Record

The Self-Regulated Learning Record (SRLR) is a proposed component that records the user's interactions with learning objects and other educational tools. The self-regulated learning record provides an alternative approach for the communication between LMS and different types of learning objects. The content of the self-regulated learning record can be accessed by any

LMS or educational tool, which in turn supports self-regulated learning. In the proposed online learning object system, the SRLR stores information related to the learner and his/her use of learning objects. This information includes the following:

- Time student spent on each learning object per session..
- The results of students' learning styles and learning strategies assessments.
- The results of students' self-assessments.
- Students' navigation behaviour in each session.

6 EVALUATION METHODOLOGY

This section presents details of the research methodology that was adopted to evaluate the educational effectiveness of the proposed learning object system. These details include a description of the research participants, design, and procedure. In addition, the instruments that were used to collect the data are described. This section concludes by describing the data analysis techniques used to analyse the data and how the results were interpreted to test the hypotheses and answer the research questions.

6.1 Research Design: Quasi-experimental Study

The qualitative portion of the study follows a quasi-experimental control group design with pre-tests and post-tests (Creswell, 2012). Quasi-experimental design is the same as the control experimental design except that the participants are not randomly assigned to the experimental conditions. Rather, intact convenience groups are used. This design is commonly used in educational research due to difficulties associated with randomly dividing participants into groups. The purpose of the experiment is to determine the effect of the proposed educational intervention on students' academic achievement in a core computer science course.

6.2 Description of the Course and Participants

The participants in this study are students enrolled in the programming languages and paradigms course at the University of Newcastle, Australia, in the first semesters of 2011 and 2012 respectively. The overall sample size was 62 students: 34 in 2011 (control group) and 28 in 2012 (experimental group).

The online learning object system is used and evaluated in the course Programming Languages and Paradigms. A course that covers programming language concepts is important for computer science and software engineering students and such a course is an integral part of any computer science and software engineering program (IEEE/ACM, 2005). Programming language concepts are presented by comparing the features of programming languages, such as Java and C++. In addition, several programming paradigms are discussed and compared. The Programming Languages and Paradigms course at the University of Newcastle is a compulsory second year course for undergraduate students enrolled in the computer science and software engineering programs. The course follows a traditional teaching method that consists of weekly lectures and workshops.

6.3 Data Collection Instruments

A number of data collection instruments were utilised to address the research the following research questions:

- What is the effect of the proposed learning object system on students' academic achievement?
- To what extent are students satisfied with the educational effectiveness of the system?

The following instruments were used to collect both quantitative and qualitative data.

6.3.1 Students' pre- and post-tests

Students tool the pre-test in both the experimental and control groups at the beginning of the semester, and before the experimental group was introduced to the online learning object system. The pre-test consists of questions to help students refresh their knowledge about several object-oriented and data structures concepts, and how to apply them to solve a real-world problem.

6.3.2 Students' Satisfaction Questionnaire

This instrument is an online questionnaire completed by students to evaluate the educational effectiveness of the entire learning object system at the end of the semester. This instrument includes questions about students' perceptions of the educational effectiveness of the online learning object system. The questionnaire utilises a 7-point Likert scale, with 1 representing strongly disagree and 7 representing strongly agree. The questionnaire consists of dimensions that are related to a specific feature of the online learning object system. Each dimension has a number of questions.

6.3.3 Self-regulated Learning Record

Self-Regulated Learning Record (SRLR) is a component of the online learning object system that automatically logs all activities performed by students in each session. This includes the frequency and time spent on learning objects and the results of students' self-assessments. Also, the students' navigation behaviour in each session can be discovered by extracting the information stored in the SRLR. The data collected using the SRLR was used to study students' behaviour inside the system.

6.4 Method and Procedure

The study was conducted in two consecutive phases. In the first phase (first semester 2011), the control group did not receive intervention and were taught using the traditional instructional approach. In the first week, students were given an information statement that described the research objectives and invited them to participate. Those who agreed to participate signed a consent form that indicated that they were willing to participate in the research study as described in the information statement. Then, the Index of Learning Style (ILS) was administered to students who signed the consent form to identify their preferred learning styles. In addition, the Self-Regulated Learning Strategies Questionnaire was administered to students to measure the level of use of different self-regulated learning strategies. In the second phase (first semester 2012), the experimental group received the online learning object system as an educational intervention to aid in developing self-regulated learning strategies while studying the course material. The Index of Learning Style (ILS) was given to the students at the beginning of this phase using the same questionnaires that were used in first phase. However, in the second phase, additional research instruments were used to measure the educational effectiveness of different aspects of the research intervention. These include the students' satisfaction questionnaire and the self-regulated learning record.

7 RESULTS AND DISCUSSIONS

7.1 The Result of the Quasi-experimental Study

The first step to evaluate the educational effectiveness of the intervention is to report descriptive statistics that describe the academic performance of the students in the control and the experimental groups. The second step is to perform hypothesis testing. This is the formal procedure used by statisticians to accept or reject hypotheses. The statistical level of significance (α) is set to 0.05 for hypothesis testing. The analysis also evaluates the influence of students' learning styles and level of self-regulated learning on their academic performance in both groups. An analysis of students' behaviour in the online learning object system was also conducted. An analysis of covariance (ANCOVA) was used to measure the difference between the control and the experimental groups while taking into consideration the possibility of pre-existing differences between the two groups.

In the control group, the mean final exam score was 55.2, while it was 65.3 in the experimental group. To test whether this difference is statistically significant, a one-way analysis of variance (ANCOVA) was used. The following hypotheses were formulated:
H0*: there is no significant difference in the final exam scores between the control and the experimental group.*
HA*: there is a significant difference in the final exam scores between the control and the experimental group.*

The independent variable is the medium of instruction, which consists of two levels, traditional or intervention. The dependent variable is students' achievement scores on the final exam. Students' scores on the pre-test were considered as the covariate in the ANCOVA to control for the pre-existing differences between the control and the experimental groups (Table 1).

Table 1: The result of the statistical test for the final exam scores comparison.

Group	N	M	SD	F	P
Control	34	55.2	15.9	9.83	0.003*
Experimental	28	65.3	19.5		

The result of the ANCOVA was significant (F =9.83, p=0.003 <0.05). Based on this result, the null hypothesis (*H0*) was rejected and we accepted the alternative hypothesis (*HA*) that the difference in the mean final exam scores between the experimental and control groups is statistically significant. Students in the experimental group (M=65.3, SD=19.5) significantly outperformed those in the control group (M=55.2, SD=15.9) on the final exam after considering the pre-test scores as a baseline for both groups. Thus, regardless of the pre-existing difference in students' achievement on the pre-test between the study groups, the online learning object system had a statistically significant positive effect on the final exam scores of the experimental group.

7.2 Students' Satisfaction

At the end of the semester, the final feedback questionnaire was made available online inside the learning object system. This questionnaire measured students' degree of satisfaction with the learning object system. The satisfaction questionnaire consists of a number of dimensions; each measures students' satisfaction in terms of their perceptions about a specific feature of the online learning object system Nineteen (experimental group) students completed the questionnaire at the end of the course. This section summarises the analysis of students' responses to the questions related to each dimension in the questionnaire. Each dimension consists of a number of questions. Students responded using a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The average percentage of students who responded to each level of the Likert scale was calculated for each dimension.

The first dimension of the questionnaire measured students' satisfaction with the online learning object system in terms of their perceptions about the ability of the system to correctly identify their preferred learning style, and the system's recommendations and guidelines. The result is presented in Figure 2. The majority of students (93%) had a positive perception of the learning style identification and awareness module. They considered it to be useful in providing recommendations and guidelines that reflected their preferred learning styles. The majority of students agreed that the system helped them to identify their preferred learning styles and that the learning strategies were easy to follow and useful. The result indicates that the system helped students gain awareness of their learning styles. Thus, many of them will be aware of their learning styles in their future studies, and should be able to use this knowledge to aid their self-regulated learning, utilising the strengths of their learning styles and overcoming their weaknesses.

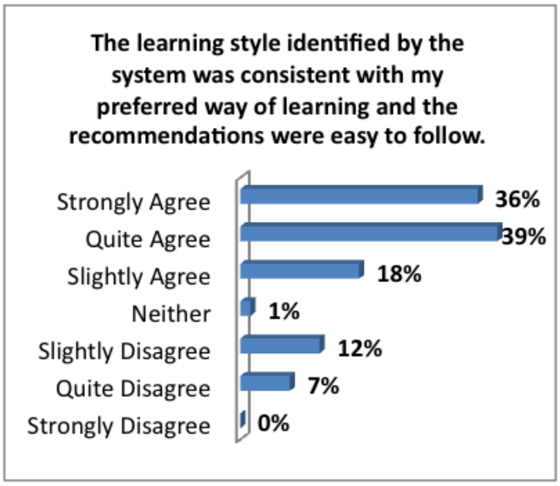

Figure 2: Students' satisfaction with the learning style awareness module.

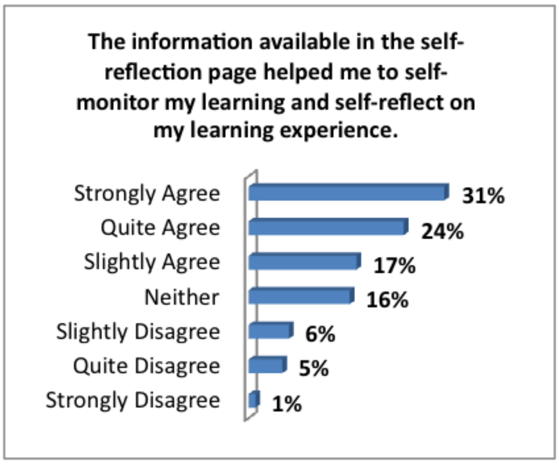

Figure 3: Students' satisfaction with the self-reflection module.

The second dimension of the questionnaire measured students' satisfaction in terms of perceptions about the self-reflection support module which was used in the system to help students monitor and control the self-regulated learning process. Figure 3 shows that 72% of students agreed that the self-reflection support module, which was used to record students' interactions with learning objects, information related to their misconceptions, and indicators of their progress, was educationally effective. Of the students, 16% had a neutral opinion and 12% disagreed with the educational benefit of the self-reflection support module.

The last dimension measures students' overall perceptions of the idea of using online learning object systems to support self-regulated learning. The result is presented in Figure 4. The final result of the questionnaire indicates that 94% of the students agreed with the statements comprising this dimension. Nearly all students strongly supported the idea of applying online learning object systems to other computer science courses.

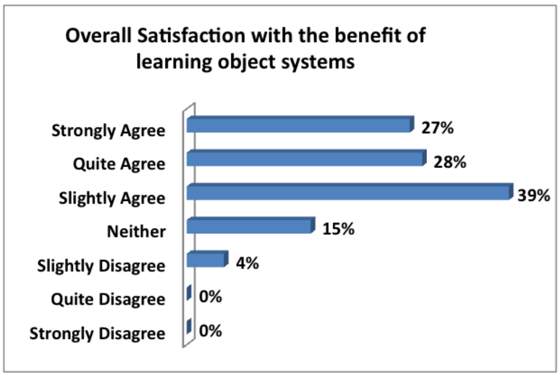

Figure 4: Students' satisfaction with the idea of learning object systems.

7.3 Analysis of Navigation Behaviour

Trace analysis of students' navigation behaviour was conducted to study students' behaviour inside the system, using the information recorded in the self-regulated learning record. Based on the self-regulated learning model used in this study, we proposed a navigation behaviour analysis method to classify learners' self-regulated learning behaviour. A number of navigation behaviour patterns were observed. We conducted further analysis only on the patterns that were followed frequently. These patterns were categorised as follows:

Browsing: this behaviour implies that students jump between different pages inside the system in the same session without spending more time on the learning objects or their self-regulated learning record.

Unplanned View of Learning Objects: this behaviour implies that students view learning objects that are most likely not related in the same session. Students who adopted this behaviour typically did not complete a self-assessment after viewing the learning object.

Inefficient Use of Self-assessments: this behaviour implies that the student tends to take self-assessments for different topics in the same session without or with a limited view of learning objects and their self-regulated learning record inside the system.

High Level of Meta-cognition: this behaviour implies that students tend to follow a navigation path that is consistent with the self-regulated learning model. They tend to view their self-regulated learning record at the beginning of each session, then view learning objects related to one topic only, complete self-assessments and spend time reading the feedback after submitting the self-assessment. They also tend to make decisions based on their results in the self-assessments, such as viewing learning objects again and then completing the self-assessment again.

Table 2: Navigation behavior patterns.

Navigation pattern	Proportion of students
Browsing	14%
Unplanned view of learning objects	14%
Inefficient use of self-assessments	18%
High level of meta-cognition	54%

The proportion of students who frequently adopted each navigation pattern is presented in Table 2. More than half of the students (54%) adopted a behaviour pattern that reflects a high level of meta-cognition inside the online learning object system. Of the students, 18% showed a tendency to adopt navigation behaviour that reflected inefficient use of the self-assessment exercises and 14% frequently adopted a behaviour that reflected browsing behaviour or unplanned view of learning objects.

Further analysis of the data was conducted to investigate the influence of the most frequently adopted navigation behaviour pattern on students' academic achievement as measured by the post-test. To facilitate the analysis, the three groups who did not adopt the meta-cognition pattern frequently were combined together to form one single group (non meta-cognition). After that, an ANCOVA test was conducted to test if there is any significant difference in the post-test scores between students in the meta-cognition pattern and the non-meta cognition pattern groups, after controlling for their pre-test scores. Table 3 presents the result of the ANCOVA statistical test.

Table 3: Navigation patterns.

Navigation pattern	Mean	SD	F	P
Meta-cognition	74.9	12.2	7.68	0.010*
Non meta-cognition	54.3	20.9		

Table 3 shows that the meta-cognition behaviour pattern group had higher post-test scores (M=74.9, SD=12.2) than the non meta-cognition group (M=54.3, SD=20.9). The result of the ANCOVA test confirms that this difference is statistically significant after adjusting for the pre-test scores, (F =7.68, p=0.010 <0.05). To sum up, students who adopted the meta-cognition behaviour pattern more frequently had higher academic achievements as measured by the post-test.

8 CONCLUSIONS

This paper presented the result of an empirical study that evaluated the educational effectiveness of an online learning object system to support self-regulated learning of programming languages concepts. The system design was based on a pedagogical framework that was adopted to improve the role and impact of learning object repositories. The result of the study revealed that the learning object system is an effective intervention in supporting students as self-regulated learners. This was also reflected in the results of the students' satisfaction questionnaire, which showed that the students had positive perceptions of the features of the system.

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Towards Commercial eBook Production in Small Publishing Houses

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Keywords: Enhanced e-Books, ePub, e-Readers, Authoring Tools, Device-independent Contents.

Abstract: In this paper we present the rationale behind e|ditor, a tool for online edition of digital contents aimed to small publishing houses. Its goal is to provide them with a user-friendly tool for creating (autonomously and at a commercially viable cost) a wide variety of device-independent enhanced e-books, including pocketbooks, pop-up e-books, school textbooks and extracurricular activities e-books.

E|ditor is content-centric, focused in the content creation process. The standard export formats currently supported are EPUB (specially indicated for pocketbooks), SCORM (for LMSs) and HTML5 (for more powerful contents, aiming specially to school textbooks). This provides publishing houses with an appropriate spectrum of formats to cover a wide range of e-book types.

This paper describes the main requirements of e|ditor and the design decisions taken to guarantee platform-independence and content reusability whereas providing a general purpose enhanced e-book creation tool.

1 INTRODUCTION

Traditional book publishing houses face nowadays several challenges to their survival. The adaptation to the current digital era, where contents are increasingly consumed in digital form, is one (if not the biggest) of them. The technological evolution of e-readers and the already widespread use of smart-phones and tablets are changing at a fast pace the way users consume digital contents, and this is producing drastic changes in the traditional publishing markets.

The pocketbooks market has been suffering an important shift from printed books to e-books, in the same way as it has already happened to music distribution from physical supports to online/electronic support (e.g. iTunes or Spotify).

Publishing houses specialized in pop-up books have found an strong competitor in digital content producers, as online multimedia interactive contents are more attractive to catch the child attention and are easily placed right at home through Internet.

The school and educational book publishers are also experiencing in the last years how their markets move towards the use of new technologies. The arrival of native-digital children (Prensky, 2001) to the education systems and the pressure of public educative administration initiatives, like the ones fostered by the European Schoolnet (EUN) (www.eun.org) or the *UK Technology Enhanced Learning Program* (http://tel.ioe.ac.uk/), are forcing them to provide learning contents also in digital form, and to fully design those taking into account all the possibilities of digital technologies. This transition faces two main difficulties. The first is that the educative community is still learning how teaching resources, methodologies and relationships should be better adapted to properly incorporate digital technologies into the educative process (Vrasidas and Glass, 2005) (Underwood, et al., 2010) (Cachia, et al., 2010). The second is the maze of continuously evolving content formats and device platforms.

The launch of the Amazon online shop in the nineties, the appearance of Amazon Kindle e-reader in 2007 and the recent moves of the main device-platform providers, taking advantage of their dominant position to place their online shops (e.g. Google Play or Apple iTunes) as the default source of digital contents in their platforms, have made evident to publishers the need to adapt their markets to the distribution of digital contents before it becomes too late.

The need to ensure that small publishing houses succeed in adapting to this big market change is not a matter of business diversity. It is a matter of cultural diversity survival, as small publishing houses are the ones more directly linked with minority languages and cultures dissemination, and with promoting independent thinking and points of view (Carroll, 1985). But small publishing houses have no power over the "digital ecosystem", so they have to ensure that their contents adapt to the functionalities provided by the most common device platforms, that their formats adapt to the ones supported by their most common tools, and that their distribution channels are easily accessible on them. Moreover, they will have to adapt their tools and their existing contents to future changes on all those platforms. But small publishing houses suffer the lack of tools adapted to this new scenery. Big publishing houses have resources to develop self-tailored tools for that purpose, but small publishing houses have not.

In this article we introduce e|ditor, a platform designed to provide publishing houses with a tool to produce format-independent and device-independent contents. It has been developed in collaboration with small publishing houses whose markets range from school and educational books, to pop-up books and pocketbooks. We describe the requirements identified and the approaches followed to face them, as well as the rationale behind those decisions. We also give a general view of the resulting platform.

2 BACKGROUND

Although there are tools available to create digital contents, small publishers suffer the lack of tools supporting the full creation process and aiming to a wide range of book types.

Almost all the tools available for pocketbook creation are meant for converting existing digital contents to EPUB, an open e-book standard format designed for reflowable content that makes use of XHTML and CSS and is extensively supported by current e-reader devices and software. One example is the open source tool *Calibre* (Goyal, 2006), which allows the conversion of a wide range of document formats to the main e-book formats (EPUB, MOBI, pdb, etc.). But just translating conventional contents to EPUB is not the best way to take full advantage of digital contents. SIGIL (Markovic, 2009) is one of the few that supports e-book creation and can export them to EPUB. But this desktop application is designed only for pocketbook creation, does not allow interactive content and has no support for content reuse or collaborative edition.

Last versions of Adobe InDesign and QuarkXPress support exporting to e-book formats. But they do not create enhanced e-books. Instead, they just convert plain paper books to plain e-books.

Apple offers *iBooks Author* for e-books creation, but it is provided only to sell them through iTunes Store, and cannot be exported outside it.

EXeLearning (Univ. of Auckland et al., 2006) is an open source authoring application to assist teachers in web content publishing. It is a desktop application and allows exporting to SCORM format and to self-contained XHTML web pages.

With regard to tools for creating digital educative contents, the efforts from educative administrations have led to the creation of tools like *Cuadernia*, *Constructor*, *JClick*, *Hot Potatoes* or *Ardora*.
Cuadernia (Junta de Castilla la Mancha, 2008) and *Constructor* (Junta de Extremadura, 2005) allow the creation of several types of interactive activities and their packaging following SCORM (a collection of XML based standards used in web based e-learning).
JClick (Generalitat de Catalunya, 1992) provides a set of computer applications to develop different types of educational activities like puzzles, associations, text exercises or crosswords.
Hot Potatoes (University of Victoria, 1998) is a suite of six applications to create interactive jumbled-sentence, crossword, short-answer, multiple-choice, gap-fill and matching/ordering exercises. It can export to SCORM format or as HTML.
Ardora (Bouzán Matanza, 2008) is an interactive exercises creator. Its contents use HTML5, CSS3 and JavaScript, and can be exported to SCORM.

None of these applications support collaborative work or "book collections" (where the book design is common and uniform through the entire e-book collection). All of them are meant for independent authors that want to create a specific type of e-book content and rarely (only SIGIL) support all the e-book process. They are usually format-centric designed, more centred in translating contents to a specific format than in the content design. They are neither meant for content reuse nor to ease future content republishing in new formats or styles. They are not web applications (centralizing the content storage) and have to be deployed in the user PC, what restricts the platforms that can be used for edition (usually only Windows, Linux and Mac). Even worst, only a few of them generate device independent contents. *Cuadernia* and *Constructor* create Flash contents, and *JClick* generates Java Applets, limiting the platforms on which they can be displayed. All these reasons make them unsuitable for small publishing houses.

3 GOALS

The e|ditor project focuses on the development of an e-book editor for small publishing houses. The key needs identified are:

- *Full e-Book Creation Support*. It must support the whole e-book creation workflow, allow mixing all types of contents and seamlessly integrate them in the same e-book.
- *Collaborative Edition*. It must support collaborative content creation, centralize e-book resources, user management and maintenance, and allow both deploying it internally at the publisher IT infrastructure and providing it externally as SaaS (Software as a Service).
- *Support to "book collections"*. It must support the creation of book collections, with the same formats and structures. This is typical of textbooks, where the books for the different subjects follow the same structure and aesthetic.
- *Flexibility*. It must allow using the appropriate structures for the types of books produced by a typical small publishing house.
- *Content-centric*. Contents must be stored using a semantic/structured organization, not in any final e-book format. This pursues two goals:
  - *Simplify content revision and reuse*.
  - *Format independency*. It makes easier to use "write once, export many" approaches. This will allow publishers to easily and cheaply adapt their e-book catalogue to new formats.
- *Platform Independency*. e-Books must be readable in as many platforms and devices as possible. For this goal is crucial the intensive use of official and de-facto standards.
- *LMS Integration*. Support for LMS integration through the SCORM standard.

These goals have guided the design of e|ditor. The following section describes its architecture and the workflow supported by it.

4 ARCHITECTURE

E|ditor has been designed as a web application. This allows its use either as SaaS, hosted by an IT provider, or as an Intranet server application, hosted by the publishing house. In this client-server architecture the centralized server application is the host and the user's web browsers are the clients. Access control is provided through user/password identification. E|ditor is composed of four modules: authentication, edition, layout specification and export (see Figure 1). This keeps tasks independency and allows assigning different task to different user.

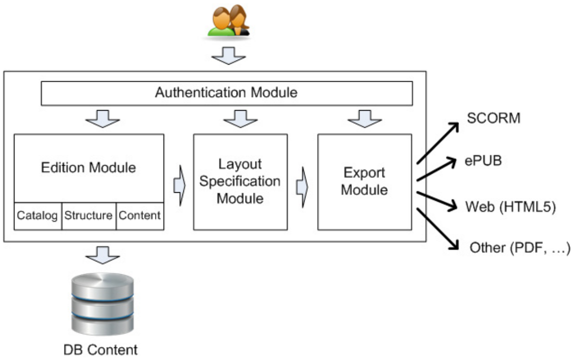

Figure 1: E|ditor functional architecture.

All the data are stored in a database. They are stored independently of its final layout and export format, so that new layouts and export formats can be used later with the same e-book content.

4.1 Edition Module

The edition module has three sub-modules: catalogue, structure definition and content edition.

4.1.1 Catalogue

This sub-module handles the e-book metadata. It follows the Dublin Core Metadata Element Set (DCMES) (Dublin Core Metadata Initiative, 1999), endorsed by standards like ISO 15836:2009, ANSI/NISO Z39.85-2007 or IETF RFC 5013.

4.1.2 Structure Definition

This sub-module predefines how the contents will be organized in the e-book and the type of contents valid at each level.

For example, in Figure 2 a *text* section is declared, having three sub-elements: *introduction*, *subject* and *conclusions*. *Introduction* can have only textual content whereas *subject* and *conclusions* can have both text and interactive exercises (Section 0 shows the supported types).

It is possible to clone the structure specification to reuse it within an e-book collection.

This information is used by the edition module (see Section 0) to keep a uniform structure within the e-book and by the layout specification module (see Section 0) to define the e-book layout.

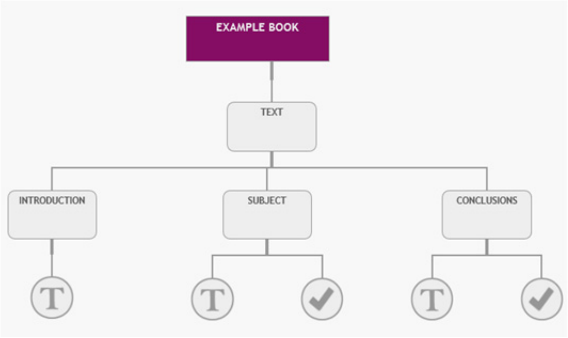

Figure 2: Structure specification.

Figure 3: Content editor.

4.1.3 Content Edition

This sub-module handles all the tasks related with e-book content edition. It manages the e-book index and the content editor.

Editors must define first the e-book index. For each index element they set its content type. The e-book structure definition is used at this point to ensure that a valid content type is chosen. After an index element is defined its content can be introduced through the content editor. The content types that can be associated to an index element are:

- *Conceptual Content*. The core textual content in a book. This is usually the only content type in pocketbooks, and is widely used in textbooks.
  A WYSIWYM HTML editor is used that annotates the content parts semantically. The layout specification module uses this to format them properly. For example, if we tag content parts as poem, definition, highlighted note, footnote or bibliography, specific styling and layouts can be applied to each one.
- *Interactive Exercises*. Exercises to be made by the users/students. The answers are corrected automatically, giving them immediate feedback. They are used in pop-up and school textbooks.
- *Scenery*. Sceneries are sections composed by animated/interactive content. They are intended to provide some light interactive animations, mainly in pop-up books.
- *Links*. A links block is meant to present a collection of hyperlinks, either to other parts of the book or to external resources.
- *Glossary*. Intended to group a glossary of term definitions. It can be used as an interactive glossary, allowing users to look the definitions right at the points where the terms are used.

Interactive exercises are used in school textbooks, complementary activities and educative books. The following types are supported by e|ditor:

- *Multiple-choice Tests*. Editors write one right answer and three wrong. For each one, they can write an explanation to be shown if that answer is chosen. The answers are scrambled each time.
- *True/false Questions*. Editors write the question, set the right answer and optionally add an explanation to be shown once it is answered.
- *Short answer questions*. They can be answered with a word or a well defined short text. Editors write the question and up to three possible right answers. The user answer must match exactly, with no variations in uppercases or diacritical signs. This is done to reinforce proper writing.
- Matching/ordering exercises. The typical exercise where the user has to match pairs of words/sentences or order a list of words.
- *Crossword Puzzles*. E|ditor allows loading JCross files created with *Hot Potatoes*.
- *Gap-fill Exercises*. Editors write the full exercise text, enclosing with # characters the text to hide. The user must type the missing text, which is corrected using exact text comparison.
- *Free-style Exercises*. They allow writing other types of exercises. Editors just write the exercise, which is not automatically corrected.

4.2 Layout Specification

This module sets how each content type is translated to an export format. This is directly linked with the structure definition and dependent on the export formats, as they impose limitations on how the contents can be shown. Several layouts (for the same or different export formats) can be defined for the same e-book. E|ditor provides layouts adapted to different export formats. They can be directly used or be cloned and modified to create new layouts.

This is the only module intended for specialized users, as layout edition requires CSS knowledge. Once defined a layout, non-specialized users can use it to visualize and export the book content.

4.3 Export Formats

E|ditor achieves platform-independence by allowing (re)exporting the e-books to several widely supported formats. Currently these formats are:

- *EPUB 2.0*. The most widely supported format in e-readers. It defines a file format (.epub) to store the contents and the e-book metadata/catalogue. Multimedia contents can not be exported to it. This is the ideal format for pocketbooks.
- *SCORM*. A standard supported by most LMSs. It provides protocols for feedback to the LMS, a transfer file format and support for adapting how users navigate through the contents. It is especially appropriate for online education.
- *Web (HTML5)*. Smart-phones, tablets and PCs provide e-book viewers with different standards support. But all of them are shipped with web browsers with HTML5 support for multimedia and interactive contents, scalable vector graphics (SVG) and mathematical formulas. Interactive whiteboards (IWB) are usually PC-based and reproduce the same types of contents. It is ideal for pop-up, school and educational e-books, as it gives more room for interactivity.

5 E|DITOR WORKFLOW

The e-book creation sequence in e|ditor is basically the following. First, the e-book structure is defined. Then, the content index is added. Afterwards, the editors write the contents. Later, additional resources are added. Finally, the layouts for the different export formats are defined. Then, the user can choose a layout and export the e-book to the format specified by it.

Anyway, e|ditor allows flexible workflows. Users can define the structure and then change it after writing some content. Layouts can be edited at any moment. And users can define only some portions of the book index, fill their content, and then add new index parts. This allows publishers to better adapt the workflow to their needs.

6 EVALUATION

E|ditor has been already in use by some of the small publishing houses involved in the project.

Publisher *Baía Edicións* has used it to create its student textbook for 2º and 4º grade social sciences and the 2º grade social sciences teacher textbook, available in web for those schools using them as classroom textbooks. E|ditor helped to guarantee a uniform structure both within a book and within the book collection, and to reuse parts of the 2º grade social sciences student book in the teacher version.

6.2. A monarquía absoluta na Francia de Luís XIV

Entre 1661 iniciou o seu reinado persoal, tras a rexencia de Mazarino durante a súa minoría de idade, Luís XIV. Desde entón e ata a súa morte en 1715, foi o monarca máis poderoso e o árbitro da política europea. Do seu reinado destacan os seguintes aspectos:

A monarquía absoluta do rei sol

Luís XIV foi o mellor exemplo de monarca absoluto , sendo imitado por moitos reis europeos. Considerábase a encarnación do Estado (*o Estado son eu* , dicía) e o centro do poder arredor do que debían xirar os demais (*o rei sol*), buscando a gloria e o esplendor persoal e de Francia.

Apoiándose nas teorías desenvolvidas por Bossuet , defendía que a monarquía e a soberanía tiñan orixe divina e o poder debía exercerse sen limitacións. Fíxose obedecer por todos; someteu os nobres, obrigándoos a vivir na corte, e limitou a autoridade dos parlamentos das provincias. Defendeu a relixión católica e tomou medidas contra os hugonotes (protestantes) franceses, prohibíndolles o seu culto público, obrigando a moitos a saír do país.

A orixe divina do poder absoluto

Deus estableceu os reis como os seus ministros e reina por medio deles sobre os pobos (...). Todo o poder vén de Deus (...). Os príncipes actúan como ministros de Deus e como os seus lugartenentes na terra (...). A persoa dos reis é sagrada (...). A autoridade real é absoluta (...) porque non existe ningún poder capaz de coaccionar o soberano, quen é independente de toda autoridade humana (...). Sen autoridade absoluta, o rei non podería facer o ben nin reprimir o mal. É necesario que o seu poder sexa tal que ninguén poida pensar en escapar a el (...). Unicamente pertence ao príncipe o mandato lexítimo; por tanto, só a el pertence a forza coercitiva.

Xacobe Benigno BOSSUET. Política sacada das palabras da Sagrada Escritura. 1679

SOCIAIS DE 2º DE ESO-PROFE

Tema 6: A Europa do Barroco

6.1. A Monarquía hispánica no século XVII 6.2. A monarquía absoluta na Francia de Luís XIV
6.3. O parlamentarismo inglés 6.4. A Galicia dos fidalgos e foreiros 6.5. A revolución científica
Reforza as competencias básicas Lembra e aplica Eixe cronolóxico Relacionamos contidos...
Materiais de reforzo educativo

Lembra e aplica

☐ Indica se é verdadeiro ou falso

1. Bossuet foi un dos máis destacados científicos do século XVII. ☐ Verdadeiro ☐ Falso
2. Luís XIV de Francia distinguise polo seu poder como monarca absoluto. ☐ Verdadeiro ☐ Falso
3. Carlos I de Inglaterra foi decapitado por non conceder dereitos ás clases proletarias. ☐ Verdadeiro ☐ Falso
4. Tras a revolución de 1678, Cromwell proclamouse novo rei de Inglaterra. ☐ Verdadeiro ☐ Falso
5. As costas galegas sufriron importantes ataques durante o século XVII. ☐ Verdadeiro ☐ Falso
6. A Guerra dos Trinta Anos enfrontou a Alemaña cos Estados Unidos e Francia. ☐ Verdadeiro ☐ Falso
7. Durante o reinado de Filipe IV tivo lugar a crise de 1640. ☐ Verdadeiro ☐ Falso
8. O parlamentarismo defende que os mercados deben celebrarse no Parlamento. ☐ Verdadeiro ☐ Falso

☐ Responde brevemente

1. O científico condenado pola Inquisición en 1633 por defender a teoría heliocéntrica foi ....
☐ Corrixir
2. O grupo dominante en Galicia, no século XVII, foi a ....
☐ Corrixir

Figure 4: *Baía Edicións*, classroom textbook.

It took just 60 person-hours to create the 2º grade social sciences student e-book using e|ditor. In contrast, the student e-book for 1^{st} grade social sciences was created in an ad-hoc manner with the support of some specifically developed tools, taking more than 500 person-hours (tools development apart) to do it. This illustrates the improvements in autonomy and costs that e|ditor achieved.

Publisher *Editorial Galaxia* has used e|ditor to create its first e-book catalogue, with 36 narrative e-books in EPUB format. It also allowed them to reuse contents to create demo-editions (with parts of the e-books) for marketing purposes.

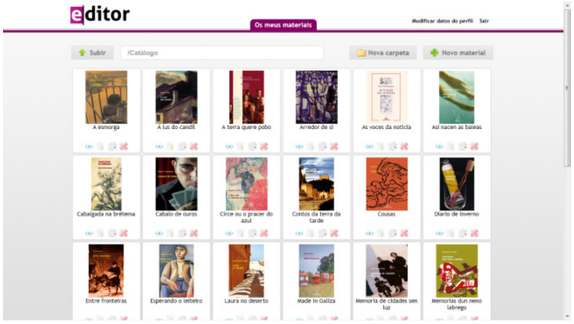

Figure 5: *Editorial Galaxia*, e-book catalogue.

Publisher *Galebook*, a small start-up specialized in digital contents, is using e|ditor for creating their extracurricular activities e-books and plans to use it also for classic-tales pop-up e-books.

E|ditor is also used by *ASPG*, an association with more than 1,000 affiliates and more than 30 years promoting educative and pedagogical innovation, teachers training and didactic contents publishing. After years using *EXeLearning*, *Hot Potatoes* and similar tools for creating their didactic contents, it is now using e|ditor for creating its extracurricular educative e-books. It plans to give a course to its affiliates in March 2013 on the use of e|ditor.

In all of these success cases, e|ditor has allowed the creation of e-books by regular users, without the need of specialized skills and at a small cost.

7 CONCLUSIONS AND FUTURE WORK

In this paper we present e|ditor, a platform to provide small publishing houses with a tool to create e-books at a commercially viable cost. It allows them to create from pocketbooks to pop-up e-books, textbooks and extracurricular activities e-books, with special care in school textbooks. It allows them to be autonomous in the e-book creation, without the need of specialized IT personnel.

The feedback from the publishers that have been using e|ditor shows that it makes them capable of creating the different types of e-books that they need, autonomously and within reduced budgets.

Although e|ditor addresses their digital content creation needs, more steps are needed to develop a solution to allow them to manage all the production, distribution and publishing processes and fully adapt their business to the publication and distribution of digital contents.

First, they need to provide users with a very intuitive and simple way to buy and consume digital contents. Users just want to easily and immediately find the right contents, buy them and consume them, without headaches. The process must be very simple and straightforward. To neglect this point would be a huge mistake, as the main e-reader and mobile devices platforms (Amazon Kindle, Google Android and Apple Iphone/Ipad) are already putting all the stress on it. They have the technological power (the platform control), and to successfully compete with them requires to make content access and consumption as easy and direct as possible.

A second issue to address is the fact that digital contents can be easily copied. Measures must be taken to reduce the risk of income loses due to piracy. This is a tricky point, because measures to avoid piracy usually go against the “easy to buy and consume” need. To find the right balance is crucial.

These challenges are not trivial, and successfully addressing them requires the joint collaboration of IT companies/researchers and small publishers to carefully analyze and address them. We are currently working in this stage in collaboration with some small publishing houses, with the aim of building the “integral solution” they need.

ACKNOWLEDGEMENTS

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Interactive Video-training for Medical Professionals

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Keywords: Information Technologies Supporting Learning, e-Learning Platforms, Interactive Language-training, ICall, Lifelong Learning, Medical Applications.

Abstract: This paper describes an innovative component of an e-learning platform targeted at second language training of medical professionals. This component provides interactive video learning material in three European languages: English, German and Spanish. The implemented prototype integrates storytelling technology with NLP and dynamic web engineering. Starting by the automatic annotation of relevant vocabulary and concepts in the domain of healthcare, our e-learning component associates the videos with external open domain resources, such as thesauri and specialized dictionaries thereby providing a comprehensive infrastructure supplying medical professionals with a situated learning environment as well as with open domain look-up and information retrieval facilities in three languages.

1 INTRODUCTION

Over the last few years, Europe has witnessed an increased mobility of its citizens and professionals. After the removal of the barriers for services such as education and healthcare in particular, more people move abroad to study, reside and work or for medical treatment. In order to facilitate this mobility, the European Union is promoting research for the development of e-learning resources and platforms for second language learning of all European languages.

A good command of the second language, in fact, is particularly relevant in disciplines such as healthcare (cf. (Leroy et al., 2010)), where a missunderstanding between patients and doctors may yield unsafe services, e.g. wrong diagnoses. Recently, much research has addressed the problem of providing high quality multilingual services in the medical domain. Most of this work addressed three main issues:

(i) Providing a unified database/ontology of healthcare terminology that can be instantiated in different languages. MeSH[1], the Medical Subject Headings maintained by the U.S. National Library of Medicine and its counterparts in other languages (e.g. German and French) are prominent examples of such a line of research (see (Nelson, 2009), (Névéol et al., 2007)).

(ii) Providing ad-hoc tools for the multilingual retrieval of scientific literature and medical databases. Most of this work addresses the problem of creating centralized catalogues and semantic indexing facilities that can facilitate the search of multilingual scientific material for reference or study (see (Kreuzthaler et al., 2011), (Grosjean et al., 2012)).

(iii) Providing translation tools for healthcare professionals. MedSLT (Bouillon et al., 2008) is an example of a multilingual spoken language translation system specialized on the medical domain. It was developed with the aim of aiding the communication between patients and doctors in real situations. It supports speech recognition and translation facilities but its coverage is restricted to a few domains (headache, chest and abdominal pain).

However, few e-learning resources exist which integrate all these research trends into a unique platform. In this paper, we describe a component of an e-learning platform specifically developed for teaching second language to medical professionals providing a comprehensive resource that supports individual learning and can be used as well as an assistive equipment in the every-day patient-doctor communication. The e-learning component presented here implements interactive video training material.

A first prototype has been realized based on storytelling technology. In the design of this component we exploit multi-media and dynamic web technology. In particular, we provide links between videos, pro-

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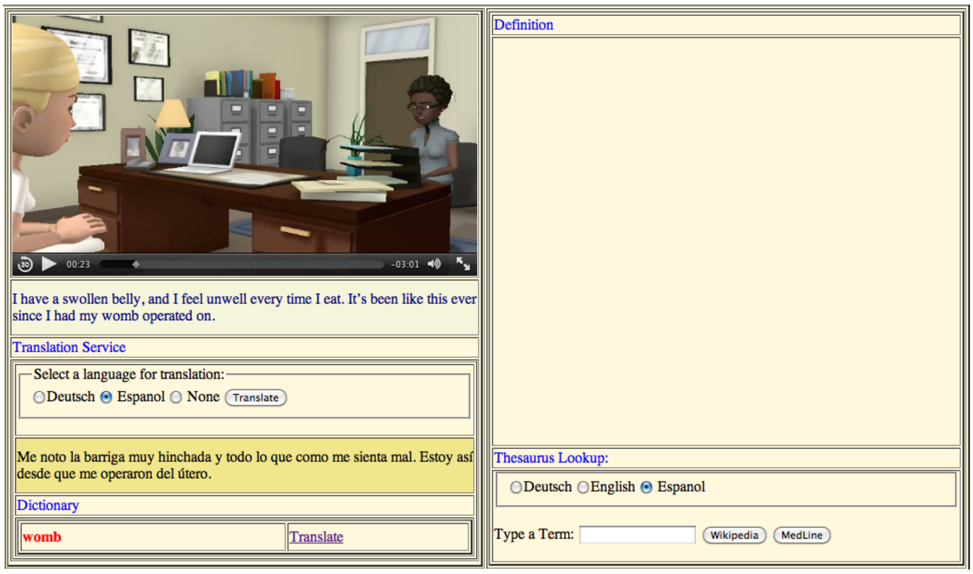
[1] http://www.nlm.nih.gov/mesh/



I have a swollen belly, and I feel unwell every time I eat. It's been like this ever since I had my womb operated on.

Select a language for translation:
○Deutsch ● Espanol ○ None

Me noto la barriga muy hinchada y todo lo que como me sienta mal. Estoy así desde que me operaron del útero.

womb

○Deutsch ○English ● Espanol

Type a Term:

Figure 1: Interactive Video Training: the GUI.

duced with storytelling and text-to-speech technology on the basis of real transcript of patient-doctors dialogues, with external resources allowing the user to interact with the content of the video and to access external knowledge.

This paper is organized as follows. In Section 2, we present the teaching methodology behind the design of the interactive video training learning component. Then we introduce the technical framework on which the implementation of the e-learning component is based. We describe the storytelling technology used to realize the video material as well as the system-user interaction model supported by the component. Finally, we show how the videos are linked with external knowledge resources. In Section 3 we conclude with some final remarks and pointers for future work.

2 INTERACTIVE VIDEO TREANING

In this section, we present the framework behind the interactive video training component implemented in our e-learning platform. We describe how video training is implemented and which features support the system-user interaction. Further, we give an overview of the external resources which are linked to the video material.

2.1 The Teaching Model

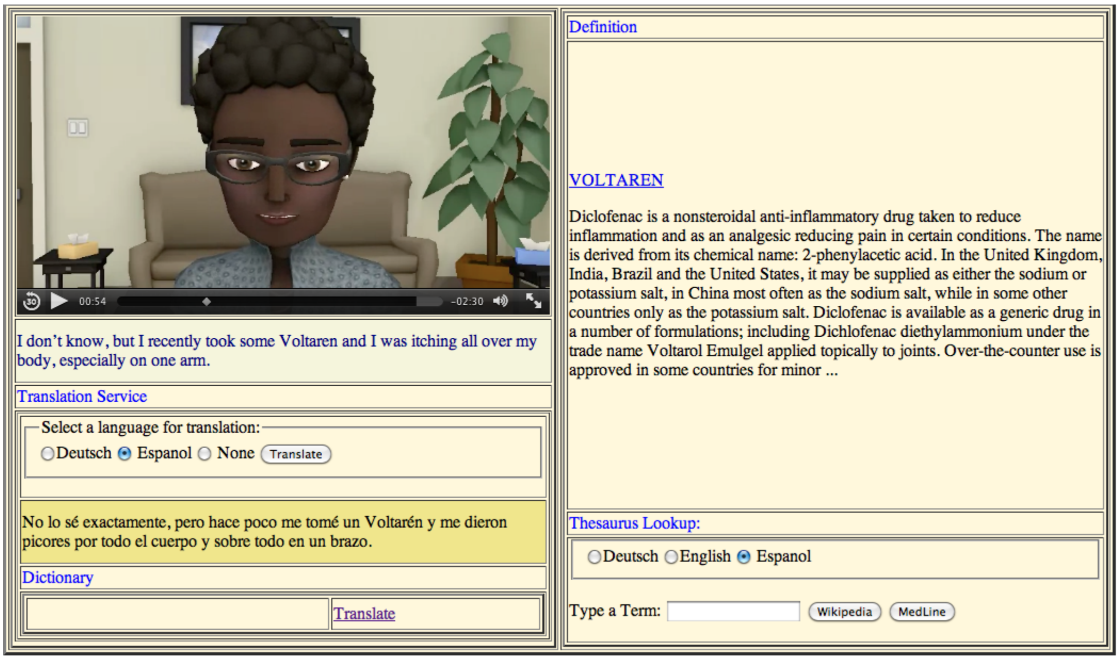
Situated learning (cf. (Lave and Wenger, 1990), (Brown et al., 1989)) is acknowledged among the best methodologies for enhancing effective second language learning, particularly in the case of adult learners. A distinctive feature of situated learning is that it presupposes that learning is linked to a real, everyday situation in the target culture and that the learner is immersed in a context where he/she can learn the language in use in that particular situation.

Further, there are several studies that highlight the role of multimedia input in enhancing learner performance and engagement. (Amoia et al., 2011)), for instance, show that children learn new vocabulary in a second language faster, i.e. more effectively and remember more words if they are exposed to both audio and textual/visual input. Video training material can engage learners more than simple text material (Zhang et al., 2006) and it represents an efficient means to implement situated learning. It further allows to fulfill several tasks required by the learning component presented in this paper, and namely:

(i) to improve listening comprehension skills of medics and healthcare givers,

(ii) to enhance cross-cultural understanding, an essential feature to assure satisfying doctor-patient interaction and safe medical services.

As we focus on language learning in communication, our learning material mainly addresses spoken interaction between patients and doctors. The e-learning component provides interactive video material in three European language, e.g. English, German and Spanish. The target learners accounted for in our framework include the following groups: (i) medical



I don't know, but I recently took some Voltaren and I was itching all over my body, especially on one arm.

Select a language for translation:
○Deutsch ● Espanol ○ None Translate

No lo sé exactamente, pero hace poco me tomé un Voltarén y me dieron picores por todo el cuerpo y sobre todo en un brazo.

VOLTAREN

Diclofenac is a nonsteroidal anti-inflammatory drug taken to reduce inflammation and as an analgesic reducing pain in certain conditions. The name is derived from its chemical name: 2-phenylacetic acid. In the United Kingdom, India, Brazil and the United States, it may be supplied as either the sodium or potassium salt, in China most often as the sodium salt, while in some other countries only as the potassium salt. Diclofenac is available as a generic drug in a number of formulations; including Dichlofenac diethylammonium under the trade name Voltarol Emulgel applied topically to joints. Over-the-counter use is approved in some countries for minor ...

○Deutsch ○English ● Espanol

Type a Term:

Figure 2: Automatic Links to External Resources.

professionals (doctors and nurses) working in a country other than their own, (ii) patients enjoying medical treatments in a country other than their own, (iii) medical professionals working in their own country but with patients speaking a foreign language.

The learning material aims at allowing self-study but also at being used as an assistive resource for reference during real patient-doctor interaction in the clinic or in the daily care work. In order to satisfy the needs of all three groups of learners in the learning component, we distinguish between the *clinical* language used by doctors to communicate with expert colleagues and the more *common, every-day* medical language used to communicate with the patients that are generally laypersons.

Doctors should be able to express themselves in the second language in such a way that the patient can understand them. Thus in the interactive video learning component, we have tried to find a balance in terminological complexity. The dialogues displayed in the videos include a language complexity that corresponds to layperson, every day medical language knowledge and specialized terminology is reduced to a minimum. So for instance in the examples below, we prefer the formulation in (1) to that in (2).

(1) *Do you have any shortness of breath, or breathlessness?*

(2) *Do you have dyspnea?*

Consequently the material can be used for learning by both medical experts and laypersons. Of course, doctors will use the term *dyspnea* in the report for the hospital and talking with expert colleagues. This more specific terminology can be accessed in our platform through the knowledge resources linked to the videos.

2.2 Video Material and Dialogues

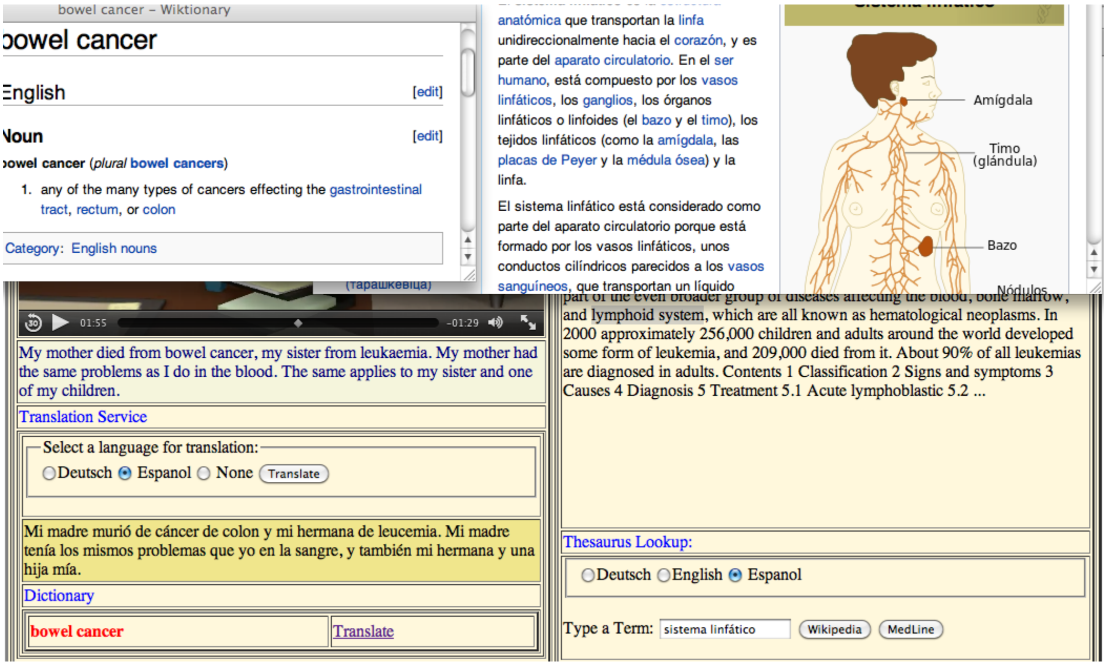
The video material included in our e-learning component aims at recreating real situations in the healthcare domain and typical patient-doctor interactions.

The videos are based on a corpus of texts including typical patient/doctor dialogues gathered by expert physicians in Spain. The topics addressed in these dialogues includes:

- putting the patient at ease,
- collecting patient demographics,
- taking a patient's medical history,
- describing symptoms,
- explaining a treatment to the patient,
- describing the effect of a prescribed medication, etc.

These dialogues have then been translated by expert translators into English and German and reviewed by doctors for checking property of language and naturalness. The implementation of interactive video material based on these dialogues includes two steps:

- creation of the video material,
- making the video interactive.



owel cancer

nglish

oun

owel cancer (*plural* bowel cancers)

1. any of the many types of cancers effecting the gastrointestinal tract, rectum, or colon

Category: English nouns

anatómica que transportan la linfa unidireccionalmente hacia el corazón, y es parte del aparato circulatorio. En el ser humano, está compuesto por los vasos linfáticos, los ganglios, los órganos linfáticos o linfoides (el bazo y el timo), los tejidos linfáticos (como la amígdala, las placas de Peyer y la médula ósea) y la linfa.

El sistema linfático está considerado como parte del aparato circulatorio porque está formado por los vasos linfáticos, unos conductos cilíndricos parecidos a los vasos sanguíneos, que transportan un líquido

My mother died from bowel cancer, my sister from leukaemia. My mother had the same problems as I do in the blood. The same applies to my sister and one of my children.

Translation Service

Select a language for translation:
○Deutsch ● Espanol ○ None

Mi madre murió de cáncer de colon y mi hermana de leucemia. Mi madre tenía los mismos problemas que yo en la sangre, y también mi hermana y una hija mía.

Dictionary

bowel cancer | Translate

part of the even broader group of diseases affecting the blood, bone marrow, and lymphoid system, which are all known as hematological neoplasms. In 2000 approximately 256,000 children and adults around the world developed some form of leukemia, and 209,000 died from it. About 90% of all leukemias are diagnosed in adults. Contents 1 Classification 2 Signs and symptoms 3 Causes 4 Diagnosis 5 Treatment 5.1 Acute lymphoblastic 5.2 ...

Thesaurus Lookup:

○Deutsch ○English ● Espanol

Type a Term: sistema linfático

Figure 3: Thesaurus and Dictionary Look-up.

We start by describing the first step. We use storytelling technology as provided by the Xtranormal[2] platform. This software is partially freely available. This system supports text-to-speech facilities and provides animated video generation from written texts, where animated characters act the patient-doctor interaction. Xtranormal allows to set the value to different features. The system

- supports 20 different languages including those relevant for our e-learning component, i.e. English, German, Spanish,
- provides different male, female and children voices,
- allows to chose between different scenarios (e.g. office, school, hospital) for the animated dialogue and different background sound effects,
- allows to set the camera angle and provides zooming facilities,
- supports different animated characters (avatars) that can walk, sit and even make up to 80 different gestures.

The videos included in the prototype of the e-learning component contain short dialogues (about 5 min) illustrating a typical situation in the medical practice in three European languages. In the next section, we describe the second step, i.e. how interactivity is managed in our component.

2.3 System-user Interaction

In order to create interactive videos, we exploit the dynamic web technologies integrated into Mozillas HTML5 media framework and Javascript. This framework allows us to manage video, audio and text material dynamically and to link our component to open data resources and web services such as Wikipedia, Google Map, etc.

In order to create an immersive and interactive video experience, we proceed in the following way. Starting from the transcript of a real patient-doctor dialogue provided by medical professionals, we produce the video, and then we automatically generate links to external resources. The written dialogues are parsed and aligned with their translations, and keywords relevant to the medical domain are extracted. Thus, those keywords are highlighted in the textual output of the component and automatically linked to external resources such as Wikipedia and MedLine in all three languages. The timeline managing the interaction with the video is synchronized with the dialogue content. This allows us to extend the video content with hypermedia experiences and links to external resources.

Thus the system supports the following system/user interactions. The user can:

- stop/start videos on demand,
- ask for annotation/transcript of the dialogue being played in the given video,

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[2] http://www.xtranormal.com/

- ask for translation of the dialogue being played in the video,
- click on highlighted words in the text transcript of the dialogue and thus access external vocabulary information, translation or linguistic knowledge relevant for these words,
- ask for further information relevant to the text topic, such as information from a thesaurus or an external dictionary,

In this way, the interactive video training component of our e-learning system provides a situated learning experience and further allows the learner to freely navigate through the linked open domain resources providing external, probably more specialized content.

2.4 External Resources

The external resources linked to the video in the prototype platform are the following:

Wiktionary. At the moment the dictionary lookup is implemented as a Wiktionary query. This choice is motivated by the fact that this resource is freely available and provides dictionaries in the three languages required by our learning component. Wiktionary also supports common medical vocabulary that is relevant to a standard patient-doctor interaction. In order to support physicians at writing specialized reports, we plan to include look-up facilities in specialized terminology resources in our component, such as MeSH.

MedLine, Wikipedia. At the moment, the dialogues are linked with the MedLine[3] database that includes a medical domain thesaurus targeting patients or laypersons, and additionally links to relevant articles, books in both English and Spanish. For German or in the case the keywords are not found in MedLine, our component uses Wikipedia lookup.

Google Translate. The system further provides translation facilities. At the moment, this service is implemented as a pop-up facility that opens a link to the Google Translate[4] service and can be used by the user for translating new words into his/her native language or in any language supported by the Google service.

2.5 The GUI

The user can interact with the video training component through the system GUI shown in Figure 1. In a typical learning session while watching the video, the learner can interact with the system by asking for a translation in one of the supported languages (English, Spanish or German). Further, the user is aided in learning new vocabulary. In Figure 1 for instance, the word *womb* is highlighted, as it is recognized by the system as a relevant keyword in the medical domain. The system provides links to (Wiktionary) dictionary entries (in the bottom left slot) and thesaurus definitions of relevant concepts (e.g. *Voltaren*, right canvas on the top). The user can decide to access this information by clicking on the highlighted word. These links are also available if the video is stopped. By clicking on the `Translate` button, a popup window appears providing a link to the Google Translate utilities that can be used to translate a term or a phrase. The user can additionally decide to look up a new concept (e.g. *sistema linfático*) in a medical thesaurus by using the thesaurus lookup slot that is provided by the system in all three languages of the project (see Figure 3).

To summarize, the user can stop the video at any time and interact with the text transcript to gather information on highlighted keywords, for instance their translation, or he/she can extract information on arbitrary medical terms from Wikipedia or other specialized databases. The innovative aspect of the component proposed in this paper is that it provides a comprehensive platform for learning and for accessing open domain resources that are directly linked with the learning component, thereby allowing learners to freely manage the language acquisition process.

3 CONCLUSIONS

In this paper, we described an interactive video training framework for teaching a second language to medical professionals and healthcare givers. The component presented here integrates self-learning facilities with external open domain resources, e.g. thesauri and specialized dictionaries, and provides a comprehensive infrastructure supplying medical professionals with both a situated learning environment and open domain look-up and information retrieval facilities in three languages. We performed a preliminary evaluation of the system mainly based on qualitative criteria and asked users to judge our system in terms of easiness of GUI navigation, usefulness of linked knowledge and enhancement of active learning

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[3] MedLine is a service of the U.S. National Library of Medicine National Institutes of Health. http://www.nlm.nih.gov/medlineplus/

[4] http://translate.google.com/

and engagement. We received encouraging feedback and plan a broader evaluation of our system in hospitals and universities. In future work, we want to extend the range of linked resources to include more specialized terminologies, e.g. MeSH. Further, we plan to develop a self-assessment component and to associate automatically generated training activities to the existent videos, such as fill-in-the-blank exercises based on the same dialogue used to generate the videos.

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Exploratory Learning in the ViStA Immersive Environment

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Abstract: Virtual Worlds have been used for teaching for several years but many issues of usage and evaluation still exist. In our Virtual St Andrews (ViStA) world, we aim to embed students within a virtual environment which is a duplicate of a real university to allow for an easier orientation to university life and a mechanism for reducing acclimatisation stress for (overseas) students. By allowing a multiple of learning approaches, including self-directed and constructive learning, our world grows organically as student groups develop areas and scenarios for future students and educators use the world for developing student skills. A variety of academic schools and English Language tutoring encourages student engagement and input. Further, Administrative and Support units within the University have been encouraged to support students by donating information or scenario scripts to be built by dissertation students. Effectively, VistA has become a cross-university educational and support system for a variety of potential and current students.

1 INTRODUCTION

The Virtual St Andrews University, ViStA, virtual world project has been developed to encourage prospective overseas students to learn and interact with the University prior to their arrival. It has engaged students and staff from several disciplines and units across the University and is the focus of student centred learning and development as well as interactive enquiry from overseas students.

Initially constructed by researchers in the School of Computer Science who have experience in other immersive environments, the project was also directed by a member of staff from the English Language Teaching service. Therefore the project considered non English native speakers as the primary client or student within the virtual world. Overseas postgraduate students coming to study in the UK for one year only for a Masters degree are faced with many urgent requirements; to be inducted and oriented within a few days, to understand the expectations of academic staff, the University's rules and regulations, to discover where buildings or staff reside as well as settle into residences or other accommodations and make contact with other students. The rationale behind the decision to build a virtual St Andrews was concluded from the experiences of many staff, and students, that one year postgraduate overseas students, especially, need some help in understanding the University system and embedding themselves within their new physical environment.

The following paper outlines some of the approaches we have taken to alleviate student stress and to follow advice garnered from student interviews and staff requirements for information to be displayed in a more interactive and enjoyable way. Part two discusses Virtual Worlds (VWs) and considers how far the educational research into VWs has come and Part three summarises the developing Virtual St Andrews project. The paper concludes with discoveries from our user trials.

2 VIRTUAL WORLDS AND IMMERSIVE ENVIRONMENTS

Virtual Worlds (VWs) are an important tool in modern teaching as well as the entertainment industries. As immersive environments they can lead the user, via an avatar with some projected identity, through a series of escapist games and interactions, or through a series of learning defined objectives. In the last decade (Duncan et al., 2011) there has been an explosion in interest in using VWs for educational purposes, from primary and secondary educational constructive learning through to Higher Educational constructs in which the student self learns and self directs.

Mennecke (2008) stated that VWs are part of the domain of multiplayer online games but without the organised gameplay. Consequently, the user can meander through a VW or interact with scenarios in a personally chosen path or meet with and work together with other users. VW examples are the Sims (http://thesims.ea.com/en_us/home), a game with multiple environments such as towns, hospitals, holiday islands to visit, or the online game worlds Second Life (http://secondlife.com/) and Active Worlds (www.activeworlds.com). In these online worlds personally designed avatars can roam, build, interact or quest. Both have educational islands (servers) from a large list of Universities and Colleges who have bought space to build an environment for their students to interact and learn in. Another system commonly used is OpenSim (http://opensimulator.org/) which is an open source VW simulator. The University of St Andrews School of Computer Science uses OpenSim to build multiple environments for students such as the Laconia Acropolis Project, St Andrews Cathedral and Castle, Linlithgow Palace, Brora Site and a Virtual Humanitarian Disaster (VHD) Simulation (http://openvirtualworlds.org/). Some of these have been built in conjunction with Scottish Heritage or with other academic schools in the University such as Archaeology or Management. The simulated worlds are rich in visual and cognitive entertainment. Users can wander through the worlds, or as in the VHD, interact with constantly changing scenarios.

Immersive environments cover a range of environments where the cognitive awareness of a user is altered by an artificial environment. The user effectively suspends partial or complete belief, enabling them to interact and react to stimuli in the artificial world. This is applicable to chess players being mentally immersed in their game, or to players within a virtual environment cave, where they have a total immersion within the world and their actions, through tactical or sensory motor accoutrements allow a complete sensation of being in that environment. Users of Active Worlds, Second Life or OpenSim have a narrative immersion when they feel emotionally invested in the experience. They may even progress to a form of spatial immersion when the game play is projected or they feel so convinced by the reality of the simulation that their awareness is totally embedded within the experience. Consequently we use the terms Virtual Worlds as well as immersion as the simulations are growing increasingly real to afford the user a sense of being in-world.

Around the world, there are many users of Second Life and Active World, latest estimates suggest these are in the range of half a billion users. The world online population, as of June 2012, is 2,405 million users with North America, Australia and Europe with the highest online penetration of over 60% each (http://internetworldstats.com). The fastest growing regions are Asia, Africa, Middle East and Latin America with online user growth rates of circa 1000% over the last decade. Asia currently has 27.5% of its population online but at over 1,076 million people this demonstrates a vast target for online educational support as well as learning within games. It is therefore necessary to summarise the types of use that researchers have made of virtual worlds to enable an assessment of the state of the art.

One of the driving forces of this work was the knowledge that many students feel stressed when arriving in a new University and a new country. According to Smith & Khawaja (2011) acculturative stressors include language barriers, educational difficulties, loneliness and some basic practical problems with finding themselves in a completely new environment. The goals for students are to achieve adaptation, socialisation and have an awareness of the host country (Lord & Dawson, 2002). The OECD (2012) indicates that there are now over 4 million international students worldwide with over 52% from Asia. Since 2000 the number of foreign tertiary students in OECD countries has doubled. Consequently an attempt to reduce either language or educational or socio-cultural stressors is a valuable goal for any educational establishment.

2.1 A Virtual Educational Taxonomy

In a Virtual World Educational Taxonomy (Duncan et al., 2012) the authors consider the primary level differentiators to be the Who (Population), the What (Educational Activity), the Why (Learning Theory), the Where (Environment) and the How (Supporting Technologies). A sixth category allows current and active research to be noted.

The *Population* category demonstrates that researchers have worked on VWs for a variety of different age groups from primary school age children up to Higher Education students. Also, some worlds have been developed for physically disabled users. Most of the published work to date focuses on higher or further education.

The *Educational Activities* category is rich in diversity from problem based learning, role playing, enquiry based learning, collaborative work, virtual filed work or even simply attending classes in-world. Myller et al (2009) presented an Engagement Taxonomy which included simple viewing (of information), as well as responding, changing, constructing or presenting. This effectively reduces to no engagement, passive engagement and active engagement. Most of the activities in this category fall into the active engagement category with users constructing artefacts in-world or discovering information and forming solutions. Collaborative simulation and constructional activities comprised over 70% of the reviewed literature here.

Learning Theories refers to the philosophy behind the educational activity. Here we have constructivist, experiential learning, collaborative, experimental, instructional or didactive approaches used with the most common being constructivist and collaborative. It is noted here that Jestice and Kahai (2010) suggested that virtual worlds can offer unique experiences consistent with situated learning theory in which learning happens within the applied context and learning is active and acquired through experience. Jarmon et al. (2009) concluded that Second Life is an effective environment for a project-based experiential learning approach because of the connection between the real world and the in-world tangible experience. Not surprisingly, collaboration and experimental constructivism were the dominant categories in the reviewed literature.

The *Learning Environment* category include the Web 2.0 based Virtual Learning Environments (VLEs) and Learning Management Systems (LMSs) as well as the 3D web based technologies which include virtual worlds.

The *Supporting Technology* category lists the variety of technologies that are optional or required within environments. These include Chat and Instant Messaging (IM), audio, streaming technologies, infrastructural aspects such as virtualisation or networking requirements such as bandwidth and port dedication. As far as the user is concerned the communication aspects and visualisation and rendering speeds are vital in aiding immersion.

Lastly, the *Research Areas* category demonstrates that current researchers are not just investigating appropriate educational strategies, learning objectives and techniques, but are also inquiring into how identity and embodiment and even geo-spatial representation affects the user's immersion. Further challenges include understanding social norms and interactions within VWs and also how knowledge passing and co-ordination of knowledge can be supportive. A separate area of growing interest amongst linguists is the use of virtual worlds to aid language learning in a more contextual environment. However, a running theme amongst most work is the problem of evaluation and assessment. Most work reviewed was descriptive from case studies and did not engage with the assessment issues.

The Educational Taxonomy described above informed the design and development of the virtual world described in this paper. The original intent was to build a VW useful for acculturation purposes, an unusual learning or educational goal. Experiential or exploratory learning was the key learning theory considered at this stage. However, as the system was developed and trialled, it was noted that the world could be also be used for educational purposes such as training within Masters level research methods modules which cover a variety of topics taught at repeated intervals to different groups of students within the University. Consequently, the *Educational Activities,* and the levels of engagement, were passive learning through active engagement with project based work, instructional and collaborative scenario building. The *Learning Environment* was the ViStA world, but the *Supporting Technologies* were essentially basic interaction and manipulation through a laptop or personal computer. Our *Population* was primarily postgraduate overseas students and our inital *Research Area* was the investigation of what overseas students would engage with for orientation and induction, especially when those actual real-world periods were time reduced in the university calendar. Secondly we desired to investigate student based learning and student directed learning, for support purposes, around specific issues of concern for overseas students.

2.2 Educational Issues in VWs

Whereas much current research is focussed on experimental environments in which students have tasks or activities to perform, several issues have arisen from our experiences in the management of these activities:

- Educators find it hard to monitor students in-world without having a constant presence which may negate student discussion or alter behaviour.
- Without monitoring it is difficult to know whether student work is truly collaborative and whether all students are engaged and

have their comments taken into account by their peer group.

- Assessment and evaluation problems then follow from the above. Formally written student reports are often used to consider their learning experiences but these are not always a true reflection of what a student has learned both academically and about themselves from their experiences. More reflection is required and appropriate assessment and evaluation methods need to be developed.
- How much contextual information or directive information should be given to students is an important facet of teaching in-world. Essentially how much do educators lead the student or is this another element that must be layered as students develop their own skill sets.
- Inclusion and accessibility is of importance especially when dealing with non native speakers or students new to VWs. If instructions are in English or the use of idioms is common, then again, we must be aware of secondary problems posed by working in an immersive, but essentially foreign, environment for new students. We should not add to their educational or social stress factors.

These issues do not allow us to fully utilise the power of immersive environments. Virtual Worlds have great potential to reach a variety of students and give them a self directed and essentially free form mechanism to discover for themselves. If educators can leverage the power of immersion within VWs, students will gain benefit from doing and understanding rather than listening. The current work in virtual archaeological field work, visual representations and interaction with algorithms, biological models and the human body as well as architectural models and police scene reconstructions demonstrate the variety of uses of VWs. However, if there are problems with evaluation and assessment we run the risk of allowing students to enjoy these worlds, without correctly assessing their work. Feedback therefore becomes problematical and grading is unlikely to be accurate. A secondary issue here may be that the types of (taught) modules which incorporate VWs need to be peer assessed or report assessed, both of which cause separate problems with accuracy or peer transparency.

A further area that has not been well developed so far are the use of these environments for either language teaching such as TEFL or for learning research methods. Both of these are important fields for overseas students coming to study in the UK. Apart from learning the language, students must write reports and dissertations in (scientific) English, and learn our systems of academic integrity, laboratory practices, statistics etc. All of these are stressful for the novice student.

2.3 Exploratory Learning in VWs

Overseas students, especially, must come to understand the cultural and academic requirements when studying abroad. No matter the country overseas students decide to study in there will be many stressful and acclimatisation situations ahead of them in finding out travel information, accommodation, matriculation, fees and visa requirements let alone finding a suitable academic school in which to study. These may not be directly educational but orientation, and induction problems affect a student's ability to settle into academic work. By developing a VW to allow a student to engage with their prospective university in advance of arrival, it is posited that the student is more engaged, and more aware of important educational and support information.

An aspect of this work is to investigate whether students follow exploratory learning patterns of asking questions (about relevant issues), investigating further (URL usage, chat, email), creating (scenarios or information for future student usage), discussing (sharing ideas and knowledge) and reflecting (through online histories of their time in St Andrews). The initial user trials demonstrate that students have followed the first four stages and the latter two are under construction with current projects. These have been driven by the students and their own enquiries based on using the ViStA world as an online orientation tool. The use of the world as a TEFL environment or for supporting teaching will now be a later phase of our continuing research and we plan to monitor the learning patterns used.

The next section describes work in building the virtual university with the primary aim of helping overseas students through their orientation and induction into a UK university. If only a few students find that a virtual university delivers appropriate contextual information and helps them, and their families, understand the world in which they are physically going to be part of, then the virtual university has been a useful exercise.

3 THE VIRTUAL ST ANDREWS

To gain entry to the ViStA world go to the URL: http://openvirtualworlds.org/ViStA/register/ and following registration one can download a viewer before entering the virtual medieval St Salvator's Quad at the centre of the University.

ViStA was originally created as a Virtual World orientation site for overseas students and has been used and evaluated by current MLitt and MSc students from the Arts and Science faculties. The original research plan was to develop a safe and welcoming environment for students considering or intending to come to St Andrews to study with us. Students would be able to peruse and interact with the simulation of the university correctly placed within the city of St Andrews. Students would therefore feel familiarity with the geographical layout of university buildings as well as discover where key resources are physically placed.

One year postgraduate students have very little time to be inducted, oriented and then embedded into their course. They also have to settle into residences and the social side of university life before producing work at Masters level, quite commonly in English as a second language. As a university St Andrews has over 2000 overseas students a year, nearly 1/3rd of the student population. Helping students understand the geography of St Andrews as well as University procedures such as matriculation and registering for modules should allow students to be more aware of their situation. Recent changes in the University calendar also reduced time spent on orientation and put extra stress on academic and support staff to publish information in a short time frame. Therefore we considered it a useful exercise to discover what essential information both new students require to know and also, what University staff need to impart, to help new students through orientation. We decided that a simulated version of St Andrews would be a useful tool to impart knowledge and to guide students through their new physical environment. The use of virtual worlds and interactive technologies allows students to get to know the University, and possibly key staff or each other, before arrival. Although this does not directly impact onto teaching and learning, we expected a positive response from students and therefore a positive effect on learning from prior engagement and a welcoming attitude from the University.

The research plan allowed us to develop structured activities to encourage friendships and contacts to ease the transition into UK Higher Education student life. Current students were also encouraged to participate by both entering the world to chat to visitors as well as develop their own (virtual) areas and interests in-world.

3.1 Work Packages

The initial plan was to achieve key outcomes from the initial build time of six months. There were four main work packages, see Table 1, and the project was managed by weekly meetings to determine short term goals.

In Work Package One we concentrated on building a virtual world geographically identical to one of the oldest parts of the University; St Salvator's Quad and the Chapel and School buildings that surround the quad today. The area was extended to include the Student Accommodation Office and the Advice and Support Centre, the ASC, which is frequently used by prospective and current students and was therefore considered vital to the virtual world.On arrival inside ViStA, a student's avatar is centred in the Quad. Currently the Schools building and the College Halls that are sited on two sides of the Quad (see Figure 1) have rooms in which students can read posters with static and dynamic information embedded in them, or view short videos that are sited in picture frames of University life in St Andrews. These videos are a mix of official University videos and student made ones from their Bubble TV student society. In a later version of ViStA the lecture theatres and rooms will be exact in details to reality but for this prototype version we kept the physical facades of the buildings accurate but kept the space inside as one large room to enable multiple avatars to mingle.

Table 1: ViStA Work Packages.

WP 1	ViStA Build: Generate the prototype world in OpenSim concentrating on the oldest parts of the University and key student services.
WP2	Orientation: Interview key staff and build scenarios and interactive avatars to demonstrate services.
WP3	Technical Storage & Virtualisation: ensure that the system can take many visitors concurrently.
WP4	Evaluation: Test the system using current students and staff and feedback information into the system.

Work Package two was concerned with interviewing key staff and current students to discover the information they considered vital to any new student arriving in the city. Although these are only at an early stage of development, as befits a prototype, we will be building more scenarios and interactive displays and in-world content over the coming months as our Honours and Masters students develop more in-world content during their project and dissertation phases.

Work Package Three was the technical support for ViSta, and other worlds, ensuring that enough computational resources were available to enable multiple visitors to be in-world at the same time. ViStA has worked well with up to 20 avatars active in-world but a trial in early Spring 2013 is scheduled to test the system with many more concurrent users.

Figure 1: Inside the Quad facing the College Halls (ahead) and the Schools buildings (right).

Work Package Four has already taken place after the initial, primary build. Students from both MLitt (Arts) and MSc (Science) courses were asked to test the system in its prototype state and to give feedback. We were encouraged by the interest of many students who wanted to build constructs and scenarios as part of their research dissertations.

These work packages were designed to allow us to grow the immersive environment and to allow domain specialists to submit information for upload to the environment. Information about University facilities such as Accommodation, Library, ELT services, IT services and academic school information could be linked to via in-world posters or leaflets with embedded links or static information. Similarly avatars could "carry" information allowing visitors to read information when close to an avatar. For example, a student representative avatar wearing the bright red undergraduate gown could hold information on where a visiting student may wish to find information.

3.2 Challenges

As with many projects scheduled to last a few months, much time was lost in discovering who in the University held information about particular processes or who had the right to allow us access to videos or film in accommodation blocks. However, as the project is planned to grow organically over the next few years, then the lateness of some information was considered non essential to the success of the initial project.

As we advertised the virtual world within the University we discovered that several units were keen to add to our environment; the Advice and Support Centre were keen to advertise their facilities and support and to offset their massive workload in the early weeks of a new academic year and the English Language support services were keen to develop avatar scenarios and interaction for language practice. Further, commercial organisations in the city of St Andrews, a small city of around 16,000 population, offered images of store fronts and lists of available wares to add to the information content of ViStA. We installed URLs to commercial organisations in their shop fronts so that the information was dynamic and devolved to the commercial organisation.

The level of immersion offered in our prototype version was low; students did not wear game wear such as helmets or gloves. Only auditory queues were available along with chat mechanisms. The system was similar to Second Life wherein avatars can move around by walking or flying and could interact by chatting. One of the many research questions that we hope to consider in future experiments is the level of immersion required by students before a benefit is measurable. Many institutions will not wish to engage in expensive interaction equipment when, or if, students are willing to suspend belief or engage with learning at a lower level of an immersive environment.

3.2.1 Information Management

Management of information was one of our major concerns and it was important that we devolved the information back to the original sources by embedding URL links to web pages as much as possible. Some information was static but we decided that any frequently updateable information was best updated by the original source so that visitors were getting the latest updated information, such as train times or cost of accommodation. Local dissemination of information was therefore important to gain buy-in from the University and from city organisations that students would frequently use such as transport companies.

3.2.2 Language Support

The original plan for ViStA was to aid overseas students' orientation so that they would engage with University work earlier and with less stress. Consequently multiple language information and interaction was a major consideration of our work. We originally planned to have in-world information in multiple languages but decided that, as the purpose was to help students orientate in a UK university, it would be appropriate to keep the main information in English. However, we also decided that it would be appropriate for some information to be offered in alternative languages, and what information this is and how it is to displayed is to be researched by students over their 2013 summer dissertations. Effectively we would have a multi-layered environment in which information could be transformed into Mandarin or Hindi if current students deem that to be necessary. Chat rooms for specific languages have been planned in the next iteration.

3.2.3 Sustainability

Essentially we see ViStA as student centred development for students and consequently the project itself should be self sustaining. As students enter the world and desire more interactivity or more language dependent information, then they can provide that functionality or resource for future students. For example, using interactive avatars to talk in a non English language was too complicated to be developed in the first prototype but this has been offered as a summer project for interested students to develop.

As the prototype demonstrates successful interaction as measured by structured interviews, questionnaires or user logs then more interaction and activities can be developed and the project should improve via student led development, subject to our analysis and evaluation. The project should have a direct effect on student activities and stress levels in the pre-sessional periods, staff- student relations and student socialisation.

3.3 Evaluation

Evaluation forms were given to two sets of students (Arts & Sciences) after a one hour ViStA taster session. Overall there were just over 30 students. The questionnaire is available online.

Most students felt they would not use the system very frequently after arrival at the University (with the system as it currently is) but they found the system easy to use and felt confident using it. They felt they knew more about the University and wanted to know more about St Andrews once they had been in-world. They found information easily and wanted to chat to more current students, but they were not keen on attending virtual lectures and there was a mix of responses for wishing to talk to staff in-world.

With the free form answers, students said they were pleased to find out more about the history and culture within the University and about Scotland and were fascinated by the 3D effects of the virtual world. They wanted to explore more of the town and University than is currently available. Some interesting points that were raised included the desire for students to see accommodation and transport systems. Whereas we had concentrated on the University as an entity with physical buildings, geographical correctness, history and basic facts, students wanted to know more about how to get to St Andrews, the cost of living and travel and what accommodation was offered.

The student questionnaire results also demonstrated an interesting facet about VWs. We call this the "Marmite Effect". Most students appeared to be fully engaged and liked the idea of a VW, wanting to be more involved as regards content, scenarios and even managing the project. A smaller but substantial group, about 1/3rd of the initial cohorts questioned, did not see any benefit of the ViStA environment. They considered the University's own web pages to be sufficient along with Google maps to discover the university's environs. The second group appeared to find no benefit in perceiving the University in-world, meeting staff and students and interacting. It was posited that this may be due to immersion factors, the lack of game wear, of the simplicity of interactions currently available (until Summer 2013) in-world. It may be that some students simply prefer their own mechanisms for finding out information and therefore, as with all educational support tools, the usage should be an aid to those who want it and not enforced in any way.

4 CONCLUSIONS

ViStA was set up initially for overseas students to help them through a short orientation and induction period. Essentially our virtual world became a cross-university educational and support system. Students were engaged with the world and wanted to develop more activities, buildings and interactions whereas staff wanted to deposit more links to information. Furthermore, staff and students both wanted to use the world for social activities, from advertising balls, sports of musical events to simply dropping into a room to have a chat with another member of staff.

Although it was originally posited that students would be keen to find out about a University's traditions, life-style and ethos, as well as necessary procedures such as matriculation and financial it was discovered that, pre-arrival, overseas students were mainly worried about accommodation and travel. Overseas students tended to hear about ancient universities through news reports or historical programs about which famous people attended the University. Online information tells the prospective student in general terms about the University and its research status, but students really want to know about non-academic issues such as travel to the City, accommodation and University social life. Consequently, we realised that it is important to listen to what students actually want, including the perspectives of EU and overseas students as well as UK national students.

The major recommendation that comes out of this project, so far, is that more time be given to a project of this nature; where there is a technical build and information gathering phases followed by evaluation. Although most of what was planned was completed, the timescale of the project has not been conducive to finessing our scenarios or extending our information base. Neither have we achieved the language aspects that will be the focus of the next research phase of our work. However, as a prototype, the project has most definitely been a success in terms of interest from the University and from students who wish to participate for the benefit of future students.

As John Stuart Mill stated in his Inaugural Address to St Andrews in 1865 when installed as Rector, "What an utter failure a system of education must be, if it has not given the pupil a sufficient taste for reading to seek for himself those most attractive and easily intelligible of all kinds of knowledge." We have posited that by allowing students to self learn in a restricted but organic immersive environment, we have encouraged self learning and awareness through social interaction and knowledge exchange. This may not be Mill's vision of reading but it is a major form of knowledge gathering for today's students.

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Demonstration of Sorting Algorithms on Mobile Platforms

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Abstract: This paper presents a systematic approach to the implementation of a mobile framework for demonstrating of sorting algorithms. Well-known corresponding projects are listed. The pseudo-code form is discussed, together with the graphical presentation of actions. A set of atomic operations that reveal the concept of sorting algorithms has been identified. Implementations of Gnome Sort, Insertion Sort, and Quicksort are given as a portable C-style code. The presented code has been tested within a prototype application on a modern smartphone. The project was oriented towards the usage in mobile learning systems.

1 INTRODUCTION

There are many subjects and concepts within computer science. Some of them are broad and extensive whilst others are relatively narrow and specific. Sorting algorithms can be classified into the last group as long as we are not creating science from them (Vitanyi, 2007). In (Skiena, 2008) the author states that sorting is the fundamental algorithmic problem in computer science and that learning the different sorting algorithms is like learning scales for a musician. Indeed, sorting is the first step in solving a host of other algorithmic problems. Pseudo-codes of different sorting algorithms and their implementation in different programming languages can easily be found on the internet (Wikipedia, 2012), (Rosetta Code, 2012). However, the most respected reference is the 3rd volume of Knuth's encyclopedia (Knuth, 1998).

The number of mobile platforms has been increasing rapidly, and it is expected that they will influence the education process at least as much as personal computers and the internet. The benefits of mobile learning include learning from rich interactive content (in contrast to books), flexible learning locations (in contrast to PCs), and and at flexible learning times (in contrast to classrooms). Smartphones, that are becoming the more widespread mobile platforms, are introducing another interesting factor, the application market, which is the most effective way of software distribution ever. Just anyone can publish his/her application. From amongst millions of these applications, many of them are already oriented towards mobile learning.

We are definitely not the first nor alone in researching the usage of mobile applications for teaching various topics regarding computer programming. We have been directly encouraged by a recent paper on teaching sorting algorithms using an Android-based application (Boticki et al., 2012). It encourages learning by location-independent usability and by awarding students with points.

Many applications on mobile platforms resemble Java applets and other web applications. This is becoming even more frequent as new ubiquitous web technologies (e.g. HTML 5) can be directly used to develop applications on mobile platforms. Let us mention some existing web applications visualising sorting algorithms.

The web site called Sorting Algorithm Animations (Martin, 2012) provides an interesting comparison of the algorithms' efficiencies. The main properties and very formal pseudo-codes are given for each algorithm. Please, note that our goal is not the same, e.g. we do not want to only provide a plain description or comparison of different sorting algorithms.

Project JHAVÉ (Naps et al., 2012) includes different sorting algorithms. It is a client-server project where each demonstration is implemented in a special scripting language. In principle, the demonstrations of each algorithm looks differently because they are precisely created to explain each particular algorithm.

D. K. Nester set up a web page powered by Javascript, that shows the pseudo-codes for various sorting algorithms and enables the tracing of their executions (Nester, 2012). The outline of our work is very similar but we have involved mobile platforms.

2 MOBILE FRAMEWORK FOR DEMONSTRATING OF SORTING ALGORITHMS

A computer program is given by its source code. As a premise for a good design the code should be clear, difficult statements should be accompanied by explanatory comments. Moreover, graphical debuggers allow for easy observation of every memory bit, and the tracking of any program flow. However, designing the algorithm is not the same as implementing and testing it. Indeed, engineers do not learn computer algorithms only to be able to write their straightforward implementation — efficient implementations are already present in libraries. The goal of knowing various algorithms is to be capable of adapting and extending existing ones and to help in inventing completely new algorithms.

A purpose-built demonstration of an algorithm may differ considerably from the debugger approach:

- Pseudo-code can be used instead of a real programming language;
- Actions can be explained in advance;
- Explanations can be beyond simple comments;
- Additional functionality can be added such as an examination mode for testing the user's knowledge.

A wide-selection of mobile platforms already exists, and this technology is still expanding very quickly. Smartphones, handhelds, gaming consoles, tablets, and ultrabooks, all of them are mobile in the sense of portability. Developing applications that can be used on different platforms is often extremely difficult (Holzinger et al., 2012). In order to address at least a part of this problem we were interested in a rather minimal GUI, and set only a few expectations:

- A display with a least 800x480 points;
- A touchscreen display recognising click, click-and-hold, and drag;
- A sensor for detecting screen orientation;
- A virtual keyboard on demand.

We found a helpful review of a mobile interface design in (Mirkovic et al., 2011). Based on the feedback from users, they suggested that:

- All description texts that do not give extra knowledge should be omitted;
- The right colours and text sizes are very important for increasing readability and clarity;
- The usage of icons and images should be highly limited;
- Concepts from web applications helps users to transfer known user experience to the mobile application, but text input and menu organisation should resemble standard mobile functionalities.

There is a lot of information, numerical and graphical, that we want to present to the user. However, we cannot show it all in once because of the limited screen size and because this would be to demanding for the user. Some possible solutions are:

- Let the device show different data in the portrait and landscape modes;
- Use pop-ups to show detailed data about items;
- Implement different screens which can be navigated by using tabs or swipe gestures;
- Use a hierarchical presentation where different groups and/or subgroups of data can be shown (expanded) or hidden (collapsed).

We have decided to take advantage of orientation detection. The portrait view is an obvious choice to show source code. Thus, we give the largest part of the screen to that component. However, without observing data changes the user will not benefit much from watching the run of a source code. Thus we also show the table of elements as small as possible but readable. Before an algorithm is chosen, the area reserved for the source code is used to show statistics.

The landscape view serves for those presentations and interactions not realised on the portrait view. Almost all the area is occupied by a table of elements. Large elements make the user's interaction with them easier. We have added a one-line comment about the algorithm's next action. This allows for tracking the algorithm even without seeing it completely.

3 TRACKING THE EXECUTION OF SORTING ALGORITHMS

The goal was the tracking of sorting algorithms by using a set of given visual effects whilst taking into account the limitations of the target platform. Different algorithms require different approaches.

The initial decision went to the pseudo-code style used for the presentation of the algorithms. Since we aimed at the usage within a basic computer science course, the obvious choice was a procedural pseudo-code form. Hence, the sorting algorithms are composed of sentences that are either assignments, decisions, or flow control statements. As well as the syntax, we also paid careful attention to the presentation of the semantics. The inclusion of compound and otherwise complicated sentences is undesirable.

The flow control by using the `for` loop is a typical example of complex statement which is composed of an initial assignment, a condition to stop, and control actions applied at the end of every looping. Thus, we preferred `while` loops within the presentation.

In order to avoid an inconsistent handling of different semantic parts, we identify a set of atomic operations that reveal the concept of sorting algorithms. Atomic operations are those that will be emphasised on the screen, either simply by showing/changing some value or applying some graphical effect, e.g. highlighting part of the screen or doing some animation. Moreover, the atomic operations formed separate steps during step-by-step tracing. To some extent, the atomic operations correspond to the pseudo-code statements, but we would have lost all the flexibility by equating these two formalisms. The following atomic operations are necessary and sufficient:

- Changing the value of a variable;
- Starting/continuing/finishing a loop;
- Reading the value of an element;
- Comparing the value of one element with the value of another one or with some stored value;
- Swapping two elements;
- Moving elements.

We were interested in the basic form of sorting algorithms where the elements to be sorted were stored in the table and no fancy optimisations were used. We considered swapping and moving elements to be atomic operations. They were autonomous principles usually taught along the sorting algorithms.

3.1 Gnome Sort

Gnome Sort is advertised as the technique used by the standard Dutch garden gnome to sort a line of flower pots (Grune, 2012). Gnome Sort is supposed to be the simplest sorting algorithm and, indeed, it is very easy to demonstrate it. Our implementation of the algorithm is shown in Figure 1. Only the bold lines are shown to the user of the mobile application. The shown lines are slightly modified (to reduce the text width and also to make it more appealing for developers using different programming languages).

The index used by the algorithm (yes, Gnome Sort uses only one index) is for brevity denoted by variable `i` in the pseudo-code. We use function `setMark()` to mark the element on the index `i` and function `setSpecial()` to denote the elements that are already in order. We use function `CC()` to enable step-by-step tracing and to describe the current/next step.

3.2 Insertion Sort

Insertion Sort is a simple sorting algorithm that builds the final sorted array one item at a time. It is much less efficient on large arrays than more advanced algorithms, but for small arrays it can even outperform them. Moreover, insertion sort handles nearly sorted arrays quite efficiently. When humans manually sort something (e.g. a deck of playing cards), most of them use a method similar to Insertion Sort.

In our implementation of Insertion Sort (Figure 2) we use mark-up function `setCheck()` to denote elements with indices `i` and `j`, that are currently being compared, and function `setSpecial()` to mark the already sorted elements. Please, note that we omitted the details of moving the elements. Moreover, to find a proper place for a current element we do not assume the moving of each individual element. We only perform the necessary comparisons and subsequently move a whole block of elements at once. Whilst such an approach is not used in most practical implementations of Insertion Sort (at least not in those sorting a table of elements), this divergence neither change the main idea of the algorithm nor causes troubles or misunderstandings.

3.3 Quicksort

Quicksort is a divide-and-conquer algorithm which first divides elements into two subgroups and then recursively sorts these subgroups. Many versions exist of the original algorithm, which are either called a simple version or an in-place version. In our project we choose one of the in-place versions (Figure 3), i.e. an algorithm which does not need an extra space for dividing elements into two subgroups. Moreover, we used a recursive version of the algorithm, which is also the most common. The presented variant is not the original version of the algorithm (Khreisat, 2007) but in our opinion it is the most appropriate one for the use in the class.

At the beginning of each recursion pass, the indices of lower and upper elements are stored into variables `left` and `right` which are then increased and decreased, respectively. Each recursion pass ends when index `left` becomes greater or equal to index `right`. Please, note that we omitted details for function `calculatePivot()` to make the code shorter. In the prototype application we used the median of the first, middle and last elements. For the sake of simplicity, the given implementation detects the final condition at the beginning of each recursive call (we could make this decision at the end, just before each recursive call).

```
gnomeSort(table T, int n) {
  int i, prev=-1;
  setLabel("read",0);
  setLabel("write",0);
  setLabel("sourceLine",1);
  i = 0;
  setLabel("i",0);
  setMark(0);
  CC("Position starts at 0");
  while (i < count) {
    if (prev != -1) {
      setLabel("sourceLine",3);
      setLabel("i",i);
      clearMark(prev);
      setMark(i);
    }
    prev = i;
    CC("Position now at i");
    if (i == 0 || T[i] >= T[i-1]) {
      setLabel("sourceLine",4);
      if (i == 0) {
        CC("Increment position (i==0)");
      } else {
        incrLabel("read",2);
        CC("Increment position ([i]>=[i-1])");
      }
      setSpecial(i);
      i++;
    } else {
      setLabel("sourceLine",6);
      CC("Swap elements [i] and [i-1]");
      clearMark(i);
      swap(i,i-1);
      incrLabel("write",2);
      setLabel("sourceLine",7);
      CC("Decrement position");
      i--;
    }
  }
  setLabel("sourceLine",9);
  setLabel("i",i);
  clearMark(i-1);
  CC("Algorithm finished");
}
```

Figure 1: Implementation of Gnome Sort algorithm.

```
insertionSort(table T, int n) {
  int i, j, key;
  setLabel("i",-1);
  setLabel("j",-1);
  setLabel("key",-1);
  setLabel("read",0);
  setLabel("write",0);
  setLabel("sourceLine",1);
  setSpecial(0);
  CC("Skip first element");
  i = 1;
  while (i < n) {
    setLabel("sourceLine",2);
    setLabel("i",i);
    setMark(i);
    CC("Outer loop now at i");
    key = T[i];
    incrLabel("read",1);
    setLabel("key",key);
    setLabel("sourceLine",4);
    CC("[i] stored into variable key");
    j = i - 1;
    if (j >= 0) {
      setLabel("sourceLine",5);
      setLabel("j",j);
      setMark(j);
      CC("Inner loop starts at j=i-1");
      while (j >= 0 && T[j] > key) {
        incrLabel("read",1);
        setLabel("sourceLine",6);
        CC("Decrement j ([j]>key)");
        clearMark(j);
        j--;
        setLabel("j",j);
        if (j >= 0) setMark(j);
      }
    }
    setSourceLine(7);
    if (j >= 0) {
      incrLabel("read",1);
      CC("Stop inner loop ([j]<=key)");
      clearMark(j);
    } else {
      CC("Stop inner loop (j<0)");
    }
    if (j != i-1) {
      setLabel("sourceLine",8);
      CC("Move [i] to index j+1");
      clearMark(i);
      move(i,j+1);
      incrLabel("write",i-j);
    }
    if (j == i-1) clearMark(i);
    setSpecial(j+1);
    setLabel("sourceLine",9);
    if (j >= 0) setLabel("j",-1);
    CC("Increment <b>i</b>");
    i++;
    setLabel("key",-1);
  }
  setLabel("sourceLine",11);
  setLabel("i",i);
  CC("Algorithm finished");
}
```

Figure 2: Implementation of Insertion Sort algorithm.

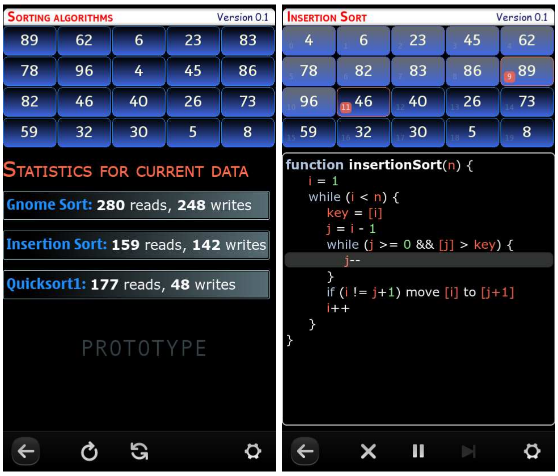
```
quickSort(table T, int begin, int end) {
  int left, right, pivot;
  setLabel("read",0);
  setLabel("write",0);
  left = begin;
  right = end;
  if (left < right) {
    setLabel("sourceLine",3);
    setLabel("left",left);
    setLabel("right",right);
    setLabel("pivot",-1);
    setSpecial(left,right);
    CC("Sort elements from left to right");
    setLabel("sourceLine",4);
    CC("Calculate pivot");
    pivot = calculatePivot(left,right);
    incrLabel("read",3);
    setLabel("pivot",pivot);
    setLabel("sourceLine",5);
    CC("Start partitioning");
    while (left <= right) {
      setLabel("sourceLine",6);
      CC("Search forward from left");
      setMark(left);
      while (T[left] < pivot) {
        incrLabel("read",1);
        CC("Element less than pivot");
        clearMark(left);
        clearSpecial(left);
        left++;
        setLabel("left",left);
        setMark(left);
      }
      incrLabel("read",1);
      CC("Element not less than pivot");
      setLabel("sourceLine",7);
      CC("Search backward from right");
      setMark(right);
      clearSpecial(right);
      while (T[right] > pivot) {
        incrLabel("read",1);
        CC("Element greater than pivot");
        setSpecial(right);
        right--;
        setLabel("right",right);
        setMark(right);
        clearSpecial(right);
      }
      incrLabel("read",1);
      CC("Element not greater than pivot");
      clearMark(right);
      if (left <= right) {
        setLabel("sourceLine",9);
        clearMark(left);
        setSpecial(right);
        CC("Swap elements [left] and [right]");
        swap(left,right);
        incrLabel("write",2);
        setMark(right);
        clearSpecial(left);
        left++;
        right--;
        setLabel("left",left);
        setLabel("right",right);
      }
    }
    setLabel("sourceLine",12);
    CC("left greater than right");
    setLabel("left",-1);
    setLabel("right",-1);
    setMark(begin,right);
    CC("Elements sorted per pivot");
    clearMark(begin,end);
    clearSpecial(left,end);
    quickSort(begin,right);
    quickSort(left,end);
  }
  CC("Return from recursive call");
}
```

Figure 3: Implementation of Quicksort algorithm.

4 DISCUSSION AND CONCLUSIONS

We have studied sorting algorithms with the goal of their demonstration on mobile platforms. There are many aspects to such work, e.g. choosing the proper presentation of the pseudo-code and choosing the proper type and amount of visual effects. Because we successfully managed three very different algorithms, we believe that our approach can be smoothly extended to the most of other sorting algorithms as well. Indeed, we do have some scruples about using the same framework for demonstrating various sorting algorithms. It could, however, be acceptable to sacrifice some flexibility for uniformity because we obtained a more direct comparison between different solutions. All in all, the shared platforms for demonstrating the problems and solutions are quite common in computer science teaching books.

When considering the practical part of the project, the main results were the implementations of sorting algorithms. When they are observed more closely, it is noticeable that each statement either belongs to the sorting algorithm, or collects statistical data, or serves as a part of the demonstration strategy. We were very careful not to mix these roles. Hence, the obtained C-style code is portable and not bound to any specific graphical API. Furthermore, we can obtain statistical



89	62	6	23	83
78	96	4	45	86
82	46	40	26	73
59	32	30	5	8

Statistics for current data

Gnome Sort: **280** reads, **248** writes

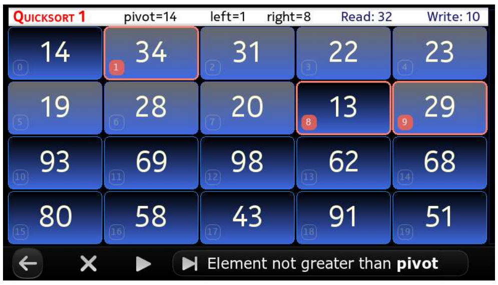
Insertion Sort: **159** reads, **142** writes

Quicksort1: **177** reads, **48** writes

4	6	23	45	62
78	82	83	86	89
96	46	40	26	73
59	32	30	5	8

```
function insertionSort(n) {
    i = 1
    while (i < n) {
        key = [i]
        j = i - 1
        while (j >= 0 && [j] > key) {
            j--
        }
        if (i != j+1) move [i] to [j+1]
        i++
    }
}
```

Figure 4: Prototype application running on Nokia N9.



pivot=14 left=1 right=8 Read: 32 Write: 10

14	34	31	22	23
19	28	20	13	29
93	69	98	62	68
80	58	43	91	51

Element not greater than **pivot**

Figure 5: Prototype application in landscape mode.

data by only excluding all GUI statements. The presented implementations were tested in a prototype application on Nokia N9. This smartphone uses Meego OS (based on Linux kernel) and allows native applications in C++. Figures 4 and 5 give some screenshots from the prototype application. In any case, the goal of the project was to research the problems in such a general way that the implementation on any mobile platform could benefit from it.
indent Although not being the main goal of this project, we found it very usable when teaching software project management. Today, students often underestimate the benefit of appropriate planning (e.g. preparation of graphical views) and testing (e.g. preparation of test cases). The presented project requires detailed planning of graphical representation because of the limited screen sizes on mobile devices, and because the effective demonstration of sorting algorithms involves several navigation commands (run, pause, stop, one step, reset, etc.), so testing the obtained application is quite a challenge.

Although, at least Quicksort algorithm is not trivial, sorting is not a real challenge for most of the students. This is not the case with all subjects. For example, when considering search trees, e.g. AVL trees, 2-3 trees, and red-black trees; have you ever been able to manage them? Every group of algorithms needs a special framework and more complex and longer algorithms are quite problematic for demonstrating on mobile platforms. Fortunately, mobile devices are becoming bigger and more powerful, capable of presenting more text and graphics, fancier animations, and effects. Also, many diverse controls are appearing (gestures, 3D accelerometers, voice commands). Hence, we all have a lot of further work.

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Crafting a Rich and Personal Blending Learning Environment
An Institutional Case Study from a STEM Perspective

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Keywords: Institutional Initiative, Design Patterns, Disciplinary Differences, TEL, E-Learning, PLEs, Co-Design, Participatory Design.

Abstract: Institutional pressures to make optimal use of space can be powerful drivers to develop technology enhanced learning approaches to traditional curricula. Engaging students in active learning and reducing the academic workload are important and complementary drivers. This paper presents a case study of curriculum development in a STEM area at a research-intensive UK university. A team of academics and learning designers have worked collaboratively to build this module as a mix of online and face-to-face activities. The module addresses professional issues, so a strong emphasis is being placed on establishing authentic activities and realistic use of social tools. It is important to the university to carefully document the development process and identify reusable design patterns that can be explained to other academics.

1 INTRODUCTION

This case study provides a reflective account of the processes needed by a multi-skilled team to develop a blended learning module. A number of target curriculum areas have been identified as candidates to establish or demonstrate educational design patterns (Goodyear and Retalis 2010). The intention is to use design patterns to explain workable and pedagogically clear responses to recurrent educational problems which will be exposed in a clear and systematic manner enabling them to be more widely understood and then reused by colleagues across the wider university.

The selection of target areas has sought to take into account disciplinary differences (Biglan, 1973) and the consequent variability in prefered practice and effective strategies across different cognate disciplines (White and Liccardi 2006). The changes enacted, and specific modules identified as exemplars typically incorporate responses to local drivers for change which can be widely recognised. These encompass imperatives beneficial to learners, the institution and to teaching academics:

This case concerns the design of a 'professional issues' module which equates with 150 total teaching + study hours taken by a mixed cohort of Software Engineering, Computer Science and Information Technology students. Typical cohort size is 150 students, with the module being taught during one twelve week semester. The module will be led by two experienced academics who have designed and taught the two 100 hour predecessor modules on which the revised module is based. Some of the content and philosophy of the existing modules are being incorporated into the new design. Both academics have a had extensive prior involvement in curriculum design and establishing teaching innovations plus a practical and research experience in technology enhanced learning. The academics are keen to preserve, yet transpose, the activities which they have observed to be effective during the predecessor modules. They are also seeking to alleviate pressure points generated by trying to manually organise the workflow generated by activities which have evolved and now incorporate a high degree of complexity. The academic expertise of the multi-disciplinary design and development team is a particular strength. Experienced teachers and researchers are working alongside learning designers have extensive practical experience. They are already skilled at specifying, designing and deploying a broad range of educational resources and online learning activities. In addition they understand the potential benefit of participatory design and co-creation which enables them to gain insights to academics' educational motivations. For this reason, they particularly value the collaborative nature of this work.

The remainder of this paper provides a structured account of the technical and pedagogic balance which has been established during this design activity. It addresses the four themes of: i) Information technologies supporting learning; ii) Learning and teaching methodologies and assessment; iii) Social context and learning environments; iv) Technology enhanced learning in STEM disciplines. It provides an account of the working methods employed and presents an interim reflective evaluation of the activity.

2 BACKGROUND

The two professional issues modules which this design is seeking to replace are both taught in a predominantly face-to-face manner. They aim to develop soft skills using authentic activities to create opportunities for situated learning. All the degrees to which this module contributes are accredited by the British Computer Society, which to some extent determines and constrains the content which is addressed and the assessment methods used Students who successfully complete the modules will have demonstrated broadly:

- An understanding of the legal, ethical and professional issues relevant to an IT specialist during their working life;
- An understanding of their personal learning preferences;
- An ability to research and communicate technical information;
- Incorporating in their routine learning practices an ability to reflect objectively and critically evaluate their own and other's work.

The teaching methods employed in the predecessor classes are a mix of large lecture classes and small group sessions. The lectures incorporate individual and group student activities and are complemented by a number of assessments including, individually: Preparing a CV; Researching and writing a technical report; Preparing an annotated bibliography; Demonstrating basic legal understanding via an online test; Undertaking an open book exam evaluating professional issues in a seen case study. As a group: Researching and making a group presentation on a technical topic; Building and creating an information resource; Creating and presenting a group poster.

The design generates some key challenges. One obvious challenge is how to consolidate the assessments for the new module. This requires careful consideration. The new module has a nominal education study and contact time which is 25% less than the two established modules.

Clearly cuts and changes have to be made. The academics have a clear sense that students' behaviours, learning and perceptions of priorities are shaped by their experience of assessment. As Boud argues: assessment shapes learning, in addition, there is a clear need in this case to craft assessments which develop “the kinds of highly contextualised learning faced in life and work” (Boud and Falchikov, 2005). This argument is consonant with Bigg's emphasis on the value and importance of ensuring that the assessments are constructively aligned with the curriculum. Furthermore it may well be possible to gain mutual benefit for students and academics. Although it is front heavy to undertake the process of structuring and framing peer reflection and evaluation to be embedded in the teaching, this process may well reward academics with long term time saving, whilst the student experience is also enhanced.

There is a particular challenge in teaching professional issues to students from the computing disciplines. Such students typically have specialised in technical subject early in their academic career; as is typical in the UK education system. Many students acknowledge they purposefully selected study options which avoid any volume of writing. In disciplinary terms, their preferences, and the bulk of the topics, knowledge organisation and study practices are those of Biglan's Hard Soft fields of study, with some overlap into Hard Pure activities (Biglan, 1973). By contrast the topics of professional issues are more closely identified with the Soft Applied fields of study. The specific challenge is identifying and using teaching methods and associated study activities which are compelling and aligned with the soft applied. In order to address the challenge consequent of disciplinary differences in the existing predecessor modules, much care has been taken in the way in which the motivation for the study area is explained to the students. The modules are presented as providing an opportunity which will enable students with an acknowledged preference for the technical focus of their chosen degrees to:

- Demonstrate a broader understanding of the professional legal and ethical issues which complements their technical expertise;

- Individually tailor a high degree of matching knowledge and understanding for topics which relate to their personal technical preferences and specialisms
- Acquire expertise in knowledge and processes which will offer them opportunities for success in the job market and during future careers.

Activities and assessments are designed to meet the ambitions of the expressed motivations. Throughout the predecessor modules, emphasis is placed on working collaboratively with fellow students and actively engaging as a part of a team; both for formal assessments and as a routine part of developing a successful approach to learning.

Although the new module will be taught in the second semester of the first year of study, it is essential that the educational resources remain accessible to the students throughout their degree. Its role in professional development also requires that to some extent resources will be available after the students have graduated. The large cohort size and a requirement for rapid feedback on assessment tasks means that significant effort needs to be addressed to the assessment component of the final system.

3 DESIGN APPROACHES

The overarching objective for the design team is to make effective use of information technologies blended with face-to-face activities to support these broad educational, organisational and administrative aims.

Building on existing experience the design team is basing their approach on an adapted version of a co-design and co-deployment methodology which has been successfully used in previous projects at the University (Millard et al, 2009). An interim model of the learning design phase of this activity is being mapped. From this, the design team are: Developing use cases which directly align with the module learning outcomes. Learner contexts include: personal characteristics of the learner; cohort cultures; time available to the learner for learning; extrinsic and intrinsic motivations for learning; pedagogical practices of instructors.

The design team are keenly aware of the importance of recognising the technology affordances of the tools which are used to realise the design. The constraints of the existing institutional meta-level technologies is as follows. Commercial products - Blackboard: Virtual Learning Environment; Turnitin; Plagiarism, grading and peer review; QuestionMark; High Stakes Assessment Engine. Local tools - EdShare: Open educational repository; ECS Notes: Linked data driven module information pages; eFolio: persistent online Portfolio: Mobile Lecture: feedback and learning analytic tool.

Whilst readers may be familiar with the functionality of the commercial tools, it may be helpful to provide a little more detail of the local ones. Computer Scientists at the University of Southampton have a history of working on hypertext, technology enhanced learning, the web, linked and open data and the semantic web.

ECSnotes, an open data driven information suite and EdShare, the institutional educational repository http:// http://www.edshare.soton.ac.uk are examples of local infrastructure tools which have been developed in association with research projects in these areas. The design team includes colleagues with a broad experience and understanding of the implementation and user interface factors of establishing repository use (Davis et al 2010). The academic team routinely use EdShare to organise and share educational resources. Resources stored in EdShare are tagged with course codes and then automatically populate the relevant ECS notes module page. Linked data, for example syllabus information, tutor profiles, student profiles, and handin specification; are automatically aggregated to a single location. Content can also be rapidly edited through wiki's embedded in the module page structure.

eFolio (http://www.efolio.soton.ac.uk) is a well-tested tool which was originally developed to support psychology students at the university and is also extensively used by undergraduates in medicine and health sciences. A further advantage of this solution is that the resultant portfolio can be accessed or exported after the student has graduated from the university (Furr et al, 2010). Since this module focuses on professional issues, the affordances of eFolio are being used to promote behaviours aligned with good professional practice from the start of the module e.g. reflection, digital literacy, online identity and portfolio development. Students will be guided into assembling a portfolio for self-assessment: auditing; evaluating; and critically reflecting upon their strengths and weaknesses in knowledge, skills and understanding within eFolio.

Mobile Lecture is a rapid feedback tool which has been developed as part of a current research project. It can be used to prompt reflection and self-evaluation of learning at the end of face-to-face sessions. It also provides learning analytic information (Aljohani & Davis, 2012). The university does not currently have any particular specialist tool in use for peer assessment. After extensive evaluation, it was decided to use mix the peer evaluation features of Turnitin for more formal peer evaluation, and WebPA as the tool to support simple developmental peer assessment.

As a matter of principle, the design incorporates the use of Open Educational Resources (OERs) where possible. The cost of developing resources from the ground up is expensive, and there is an additional objective of ensuring students become familiar with the value and abundance of OERs. The affordances of EdShare in conjunction with Blackboard are being utilised. The implementation stores and catalogues discoverable resources (including links to OERs) in EdShare. Blackboard's role is as a tool to manage the workflow. A particular strength of Blackboard and EdShare is that both tools are capable of providing learning analytic information which may be useful in the short and long term. It is intended that such information will be used by the module team and where appropriate be presented to learners to enable them to calibrate their achievements and progress. QuestionMark and Turnitin are the two remaining commercially available institutional tools. QuestionMark is used as a standalone tool for high stakes assessments. In this module, student achievement will be demonstrated by a mixture of interim courseworks and a final summative examination. Turnitin is routinely used for all submitted courseworks to check the academic integrity of students' work. However its additional affordance is also being used in the context of peer assessment.

CITE is perhaps unusual for an institutional centre for educational innovation in that its co-location with an active computer science research group ensures that there is active participation in the design process by researchers who are also highly experienced in software engineering and user design.

The learning design team have experienced a crash course in this particular aspect of computing, and have responded to the challenge. Whilst the learning curve on heavyweight design tools is significant, pragmatic modifications has enabled the team to capture and communicate their designs in a well structured and ordered manner. This resulted in a set of formal specifications articulating the workflow created following discussions and negotiations with the academic members of the team who will be responsible for the teaching.

Mock ups and walk through are used to communicate work in progress, and to validate with the academics whether the online realisation matches (or even exceeds) their specification. Since the team is relatively new, some aspects of the workflow implementation are necessarily forcing them to explore new territory. In this respect the ambition to capture design patterns has an additional strength in that it forces the team to examine and articulate implicit understandings and reflect on the replicable and compelling aspects of their experience of the design and its process.

4 CONCLUSIONS

The endeavour which the design team have undertaken is an ambitious one. The two modules which we are seeking to transpose into a blended format are both already pedagogically complex. Where the design of the existing face-to-face predecessor modules is predominantly constructivist, the realisation of the new blended module is necessarily connectivist (Siemens and Page, 2005).

When considering information technologies supporting learning the area in which we expect to experience the greatest learning is in relation to disciplinary differences and technology affordances. The students will routinely make use of a wide range of information technologies. The blended approach presents web-based learning in a formal and informal context. Students will make use of wiki's and blogs. In ECS, it is unusual to use Blackboard, even though it is the university's adopted VLE. Our students will be much more familiar with the ECS notes system. We will be closely monitoring usage of both routes into the systems. Further insights need to be gained.

Use is being made of student generated content, and we anticipate a full interim review of the system after its first instantiation. Student interns will be working to analyse the evaluation data and also to provide individual analysis and input for the inevitable tweaking and modifications and redesign. Current experience in ECS suggests that the use of linked and open data is a powerful timesaver which facilitates simple integration of diverse learning materials. The first implementation will provide an opportunity to objectively evaluate the comparative benefits of data driven consolidation with handcrafted creation.

Reflecting on learning and teaching methodologies and assessment it is believed that the higher level objective of recording, analysing and capturing design patterns will make a valuable contribution to fuelling a more informed discussion of these agendas across the university campus. It is interesting to observe the ways in which the team's working methods have evolved, and to compare them with similar, but different experiences – for example the collaborative creation of educational repositories in modern languages and the humanities.

The blended learning approach has also acted as a vehicle to purposefully design a 'flipped classroom' approach to the teaching. The design pattern and the evaluation of the experience will be valuable.

Turnitin for large-scale peer assessments has been implemented in Computer Science (Hamer et al, 2011), but is a novel departure for our university. The Southampton implementation is lighter weight than the earlier accounts and it will be interesting to compare the outcomes.

Students continue to exhibit a preference of default social software when left free to establish this social context and learning environment. However it would be possible to view this behaviour as a manifestation of the use of 'worldware' (Morris et al 1994) taken into the twenty-first century. The value of a purposeful requirement to make use of a wide range of authentic social tools, and to reflect on the viability and effectiveness of the methods chosen, remains to be evaluated.

In our local experience, the use of technology enhanced learning in STEM disciplines is not widespread. The model chosen by this initiative is to use technology as a workflow manager in conjunction with authentic tools and authentic tasks. It remains to be this experience is undermined by the acknowledged dissonance between the natural methods of predominantly hard applied fields of study compared to those which best match soft applied disciplines. One thing is sure, this particular design, and its design patterns may give us some insight. One thing which remains unanswered is whether the students will actually enjoy the experience.

The task of redesigning any area of the curriculum, whatever the discipline, is not one to be taken lightly. This paper has provided a case study of such an activity, where a specific objective of the team engaged in the redesign was to identify the pedagogic and learning design patterns inherent in blended learning.

The importance of the learning which results from producing systems, such as the one describe here, are valuable because they demonstrate a pragmatic solution to a real large scale problem constrained by existing infrastructure and established working patterns and practices. Whilst more powerful tools may exist, and ideal practices documented in the theory, transforming face-to-face teaching into effective blended learning, requires insights and understandings of the student experience in the specific context of their university studies.

The potential benefits of recording the steps required in such activities are manifold. It remains to report on a detailed evaluation of the experience; and it will be important that such evaluation considers the changes implemented and the interactions generated from the perspective of each one of the actors in the system. Perhaps most importantly the systematic acquisition and cataloguing of institutional or organisational knowledge is an activity which every university must surely value. Such knowledge can be of use to achieve diverse objectives; financial stringency, maximal student satisfaction or optimal use of all available resources. This exercise has, this far, yielded some valuable insights.

Information technologies supporting learning: There is a strong case for arguing that information technologies can be used to remove the barriers to learning. Providing access to information at anytime and anyplace makes a compelling argument.

From the academic's viewpoint, systems which manage workflow alleviate a major pressure point in the day-to-day working life at university.

It remains to be seen whether learning analytical information is as valuable to educationalists as customer profiles and analytics are to commercial organisations. It seems reasonable to assume that students might benefit from learning about successful practices (students who have a first class mark so far are looking at these web pages…).

University teaching has sometimes been described as the last cottage industry. Institutions like the UK's Open University have long established practices of working with a mixed team formally planning and creating learning resources to be integrated with specific educational experiences. Such an approach has provided a framework for much more clearly identifying and utilising preferred learning and teaching methodologies.

The systematic approach to learning design, has provided an opportunity to methodically make use of a wide range of approaches to assessment; a far wider range than might typically be found in a conventional face to face educational programme.

Students in the department were already making extensive independent use of technology for social learning activities. It remains to be seen if this structured approach will be acceptable, or be judged a poor second to the ad hoc solutions crafted from the preferred social network chosen and used by the vast majority.

At the university department being studied, there is a strong infrastructure of linked data driven module pages, many coursework submissions are electronic, and some examinations and tests take place online. Much information is published online, and some academics make wide use of the institutional repository. None the less, it is possible to argue that before this particular exercise technology enhanced learning has not widely used.

The predominant philosophy here is that technology is good for admin, but teaching and learning is a process where people and face-to-face interactions are prime. This detailed design activity is providing an opportunity to open up from that view, but it will only be more widely accepted if the student learning experience is at least as good, if not better than that afforded by conventional approaches.

There remains, of course, much future work which can be done. When the module is run it will provide a large volume of detailed evaluation data mapping student experience. Alongside routine and systematic evaluations which can be compared to previous years' and previous methods a range of different evaluation approaches are proposed.

Focus group discussions will be used to identify key strengths and weaknesses. These will be complemented by critical and reflective evaluation by academics at the end of the module. It is also intended to recruit students from the cohort to become participative evaluators and co-designers to help identify and create the inevitable and necessary revisions which will emerge.

Equally important, the learning designers will consolidate their knowledge, understanding and reflection of the process. Initial drafts of the formal design patterns will be circulated and subjected to peer review, and the whole pattern of integrative innovation will begin again.

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Mixing Reality and Virtual Worlds in an Educational Mobile Robotics Remote Lab

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Abstract: This paper describes MOBOLAB, a project aimed at the construction of a remotely controlled mobile robotics laboratory. MOBOLAB was primarily designed to aid educators who wish to use robotics as an educational tool for pupils ranging from elementary to high school, and who don't have educational robotic equipment readily available at their place, or who wish to use a standardized environment offering several useful features to enhance their teaching activity. MOBOLAB also offers other interesting usage possibilities, such as on-line training of educators, student robotic competitions, etc.

Although far from being complete (in fact, MOBOLAB was designed as an ever-expanding project), some interesting results have already been obtained from practical experiments performed with pupils and educators.

1 INTRODUCTION

During the last few years the importance of robotics, especially mobile robotics, at all levels of education has become unquestionable (Johnson, 2003). Robots are being used to teach not only the principles of robotics, but also a variety of concepts and notions spanning completely different areas, such as computer programming, geography, mathematics, etc.

The goals that can be achieved using mobile robots in the classroom are multiple, and have been discussed by several authors; they range from the understanding of what a mobile robot is and what problems it has to face in the real world (perhaps comparing them with the more structured world in which industrial manipulators operate), to the basic principles of programming (Seymour Papert's Logo (Papert, 2005) was a great precursor in this field), to a quite amusing and unpredictable teaching aid for other subjects, such as geography or math, if the robot is wandering over a map or a table that bears right and wrong solutions for a given problem.

It often happens however that schools are not equipped with robotic laboratories, and educators are not yet used to robots and require specific training. Investing in robotics equipment, especially in small schools, is often unaffordable or at least economically un-convenient.

On the other hand, remote real and virtual labs that can be accessed via the Internet have become very popular in several fields, including robotics. They offer a standard environment, possibly including also sophisticated equipment, at a very low cost given the scale factor (a single lab can be used to satisfy the needs of several schools). On the user side, they require standard devices—actually, a PC and an Internet connection usually are all that is required to start—that are already available in most cases.

2 THE PROBLEM

Virtual and remotely accessible labs are not new, not even in the field of robotics (Khamis et al., 2003). However, due to several reasons, most of the existing robotics laboratories are related to manipulation, rather than to mobile robotics.

Furthermore, they are often aimed at high school or college students, while the system described here is specifically targeted to younger pupils (up to an age of about 15 years) and to their teachers.

A distinction should be made between virtual and physical labs. The former serve data from a computer simulator of the system to be studied. Some of these systems offer very sophisticated services, as the MIND Project (http://www.mind.ilstu.edu). Anyway, in most cases, it is useless to resort to a remote simulator, since a local one can be used, unless high computing power is required. The only reason for using a remote simulator is when people located far from each other must work together or compete. This happens for instance in computer simulated games as the simulated soccer league of Robocup (Kitano et al., 1997).

Examining the pro's and con's of mobile robot simulators is not in the scope of this paper, but it can be said that, in general, they don't give users, specially the younger ones, the feeling of something physical really happening somewhere in the world. Users tend to quickly lose interest and the educational result is quite poor.

Most remote labs, on the other hand, are devoted to experiments where some physical device or measuring instrument is connected to a computer. In this case, "localizing" the experiment would require the acquisition of (often expensive) instruments. Commands issued by the person performing the experiment and measured data are directly transmitted through a computer, and this requires quite a simple procedure to provide the user with a suitable interface. In other words, the connection between the user and the real world takes place in the form of well-standardized methods and protocols.

Remote robotics labs, on the other hand, have different requirements. This is because the robot physically interacts with the real world through non-standardized, poorly modeled interfaces (the gripper in the case of a manipulator arm, wheels or legs in a mobile robot). The effects of a user-initiated action cannot in general be anticipated, and in most cases not even measured. This poses at least two additional requirements:

a) The user must be able to see, and often also to hear what is happening in the lab;

b) The lab must be capable of automatically returning to a known initial state, no matter how wrong the received commands were.

The above requirements are quite hard to meet when manipulators are involved, and usually require that some human assistance be available at the lab site. In the field of mobile robots instead, they can be more easily met if the environment and the robots are simple and carefully designed in order to avoid entanglements, robots capsizing and other major accidents.

Additionally, mobile robots need some means for recharging themselves when they are not being used. The recharging procedure should be fully automatic.

As it was said, the alternate choice of using software simulators doesn't seem to be very appealing, because simulators cannot fully replicate the real world and their users are often unsatisfied and get quickly bored (Tzafestas et al., 2006). On the other hand, the real robots, even if at a remote location, are much more appealing especially to younger people, and obviously perform in a more realistic way.

A number of very interesting and inspiring realizations in this field is already available (Guimaraes et al., 2003), (Casini et al., 2008), (Casini et al., 2009), (Casini et al., 2011): however, the project described here has some original characteristics such as the capability of being remotely controlled and programmed in different ways to accommodate the needs of different users, and the use of some augmented reality to enhance the performance of the whole system.

3 DEFINING PERFORMANCE LAYERS AND SERVICES

As it was said, MOBOLAB project is targeted to the needs of different users: students of various grades on one side, educators on the other. It must therefore be structured in such a way as to behave differently and to allow different activities, depending on the chosen level.

3.1 Common Services

From the users point-of-view, MOBOLAB is a web server that can be accessed using an ordinary web browser. A few common services, available from the home page (Figure 1), have been established to allow easy usage of the lab. These services include:

- An authentication mechanism, to allow only registered users to access the system at various levels, according to their authorization level;
- A booking system, as the lab was designed to be used by a single user (or group of users) at a time;
- A forum, which can be used as a source of information (descriptions, user manuals, etc.) and as a place for discussion among users.

All these components were implemented using off-the-shelf free software components (SMF for authentication and forum, MRBS for the reservation system).

3.2 Layered Services

In order to satisfy the needs of different classes of users, the following service levels have been defined so far:

Observation. The user at this level can't interact with the system. He/she can only observe and listen what is happening at the remote site. This level is mainly intended for demonstrations, where an instructor does all the teaching and pupils attend remotely. If bandwidth allows, this mode can be augmented with a Skype group call to enhance the presence effect.

Benvenuti in Mobolab!

Non siete ancora registrati?

Tentativamente, abbiamo tolto la limitazione ai soli iscritti per la navigazione sul forum. Speriamo che gli hacker ci lascino in pace, stavolta...

Figure 1: MOBOLAB home page.

Tele-operation. In this mode, the user can remotely control movements of a robot. At the present stage, a simple non-holonomic robot built around a Lego NXT brick is being used, that is controlled using a number of virtual buttons on the user's screen, as it can be seen in Figure 2. No programming is available in this mode, and the only automatic function available is a "return home" function that can be called at any time.

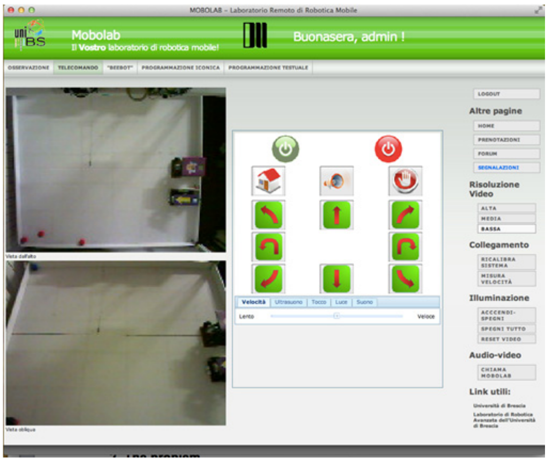

Figure 2: Tele-operation layer.

In addition, the user has a chance of getting some sensor data from the robot, and to set some parameters as rotational and translational velocity.

"BeeBot" programming. This mode (Figure 3) allows an emulation of the BeeBot robot (Demo, 2008). This machine was designed for the first approach to mobile robots, and consists in a bee-shaped robot bearing some pushbuttons on its back. These buttons allow programming movements on a flat surface divided into uniform squares (the robot can only move one square forward, one square backward, or turn 90° right or left. Steps described pushing these buttons are stored and the whole program can then be played as a sequence of movements, closely replicating some features of the Logo turtle.

This level currently uses a second robot, built around a Lego NXT brick, which was specifically designed for this purpose.

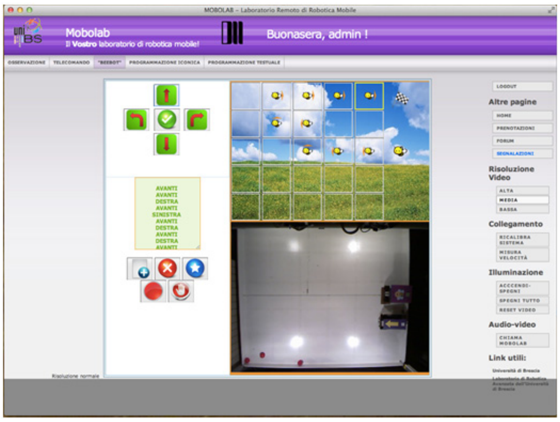

Figure 3: "BeeBot" layer.

Iconic Programming. Iconic programming is achieved using the classical Lego Mindstorms NXT-G programming language. So far, it has been implemented replicating a remote display mechanism based on VNC, and uses the same robot used for tele-operation layer.

Textual Programming. Textual programming can be achieved using NXC language. A very simple interface has been built that allows editing, compiling, uploading and executing programs written in NXC on the same robot used for tele-operation. Also this layer uses the tele-operation robot.

4 MAIN DESIGN ISSUES

Once the basic idea that real robots should be used instead of a simulator was established, it became clear that some efforts should be devoted to optimizing resource exploitation and to maximize cost-to-benefit ratio.

4.1 Bandwidth Optimization

Obviously, as far as bandwidth is concerned, video and audio transmission are the most demanding parts of the whole system. Luckily enough, in a normal configuration where the user is connected to the Internet via an ADSL connection, the fastest path goes in the right direction (towards the client). However, smaller bandwidth connections should also be taken into account.

The research followed these steps: the design criteria required that two video channels and one audio channel should be available. The video channels should carry images from two cameras placed in different positions over the lab, while the audio channel should provide acoustic feedback to the user and, being bi-directional, also allow communication with a human operator when he/she is present at the server's location.

Before establishing video and audio communication, the available connection speed is measured, and the most suitable image size and frame rate are automatically chosen.

4.2 Image Acquisition

The cost requirements of the system call for inexpensive components to be used whenever possible, and the imaging system is no exception. At the client side, low to medium resolution terminals will normally be found. Most often, a video projector or an interactive blackboard will be found due to the classroom usage, and the maximum display resolution can be assumed to be 1280x1024 px.

Since several pieces of information need to be displayed at the same time, in most cases there will be no need to resort to images at a resolution higher than VGA (640x480 px), and in many cases a resolution of only 320x240 px will have to be used in order to fit all images in the screen.

4.3 Image Processing

As testing of MOBLOAB began, it became clear that, as the lab can be used at various levels, different backgrounds were desirable. At the "BeeBot" level, for instance, kids would be amused by the possibility of switching between "natural" backgrounds (grass, flowers, etc.) and "artificial" ones (maps, arrays of numbers or letters, etc. as can be found for instance in http://www.terrapinlogo.com/bee-botmats.php). At higher levels, different tracks, obstacle-cluttered environments, etc. are desirable to perform different experiments.

The idea of mechanically changing the mat over which robots move was soon discarded because it is too complex and prone to faults, and it was decided to implement a virtual background system, following the technique commonly used in TV studios.

For this reason, a background subtraction system was implemented, that allows removing the background from images gathered by the cameras, and to substitute it with a still picture chosen by the user or by the system, according to circumstances.

So, while the real robots wander over a white floor, any static picture can be superimposed giving the feeling of the robot moving in a different

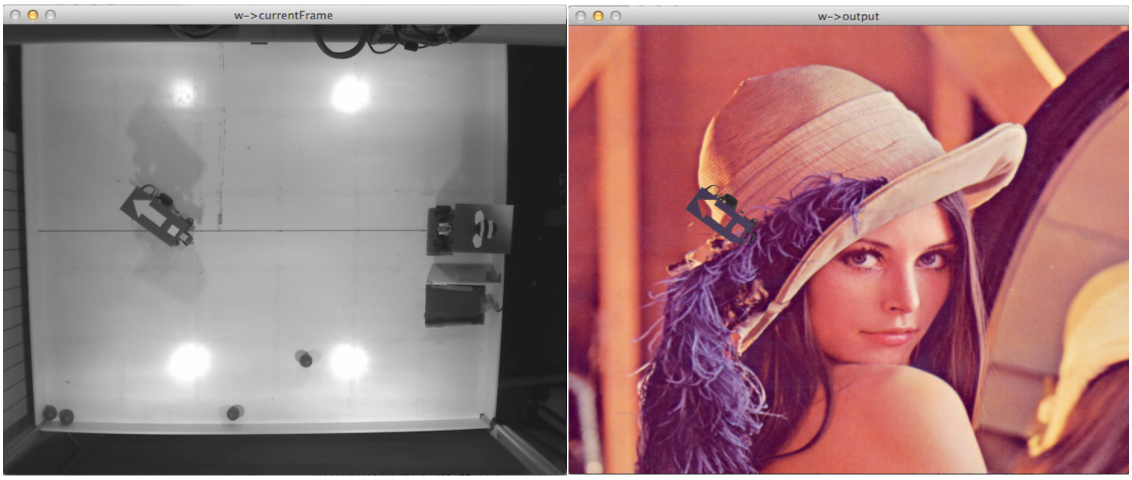

Figure 4: Background substitution demonstration.

environment, as it can be seen in Figure 4, where the white floor has been substituted by an image that is very popular among artificial vision researchers.

4.4 Pose Estimation

In its current implementation, MOBOLAB uses two robots built around Lego NXT bricks using Lego components. The precision attainable with such components is low, and position data gathered by odometry are unreliable even after short movements from a known position. This calls for an external localization system.

Luckily, the background substitution mechanism described above provides robot position data as a byproduct, and with some enhancements full pose data can also be obtained. Such data are used by several other parts of the system for driving and monitoring the robots. In order to achieve this, each robot was equipped with a unique set of passive markers, which can be recognized by the system and used to compute the robot's pose.

The used technique will also allow defining "virtual" obstacles, i.e. obstacles that can be "seen" by sensors but do not exist in reality, using a method similar to the one described in Casini et al., 2012.

4.5 Further Bandwidth Reduction

As the last two parts were completed, the idea arose that position data could also be used to synthesize robots images. In other words, the idea was that the background and each robot's image should be transmitted only once, leaving the task of correctly placing the robot's image over the background to the client, with the server providing only real time position data. This of course would almost totally remove the feeling of watching real robots, but would in turn dramatically reduce the required bandwidth, making the use of the system possible even with very poor Internet connections.

Moreover, the user (or the system) can very easily switch among the various combinations offered by the system (real or synthetic background, real per synthetic robot images, thus making the system able to cope with a number of different situations.

4.6 Other Issues

As MOBOLAB, in its current form, was clearly designed as a single-user system (there may be several observers in different places, but only one of them can be in control of the system at any given time), very simple lock mechanisms were implemented to prevent multiple users to physically access the system at the same time. Observation level, the forum and the reservation system are instead always accessible.

5 EXPERIMENTAL RESULTS

The system has so far been tested in a fourth grade elementary school class (9 years old kids), with a group of elementary school teachers (at a very basic level of robotic skills) and with some technical high school students.

All tests were performed using a laptop computer connected to a video projector, that allowed one person at a time to control the system, while all the other watched the screen (shouting suggestions in the case of younger kids).

The results seem to replicate the results reported in previous researches (Trevelyan, 2008), i.e. that remote laboratories can be very well used instead of local ones, and that the educational outcome is very good even with an extremely limited investment. An interesting consideration is that these systems seem to work best with younger people: our "digital natives" had no problem at all in learning how to use the simpler layers of the system (tele-operation and BeeBot emulation), while teachers experienced some difficulties even at these simple levels. Most problems were however related to the interface: for instance, some of the icons used for buttons had to be changed to make the more understandable to older people.

Similar results were obtained with a group of second grade pupils (7 years): in both cases the level of attention was extremely high, and at the end of the test (about three hours long) it was quite difficult to stop because the kids weren't tired at all yet.

The experiments performed with second and fourth grade pupils took place in a school located about 150 Km from MOBOLAB. Interestingly enough, no kid had any problem in understanding what was going on locally and what at the remote site. The question "do you think it is possible to control from here a robot that is located in the town of Brescia" got an unanimous affirmative answer, and some of the kids even explained how that could be achieved with a quite good technical precision, appropriately using terms as "server", "Internet", "webcam", etc.

High school students, on the other hand, were not particularly interested in the lower level services, and concentrated on the robot programming aspects.

However, they proved extremely helpful in debugging the man-machine interface and in suggesting some important improvements.

6 CONCLUSIONS AND FUTURE DEVELOPMENTS

An ongoing project was described, that aims at bringing mobile robots in schools even in underdeveloped or economically weak areas at a very low cost, using existing infrastructures and optimizing usage of equipment through sharing.

Although the to-do list still has countless items, the system is already useable and is being used in practical applications.

Among the most important additions, it is worth mentioning a better integration of virtual backgrounds with simulated sensor data, the substitution of the actual robots with more versatile ones (holonomic, and with a better-designed docking system for recharging), and a number of improvements on the user interface side.

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Arab Learners' Cultural Values and Their Interference with e-Learning

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Keywords: e-Learning, Distance Learning, Cultural Norms, Arabic Culture.

Abstract: This paper is set to identify the role of cultural norms on the adoption of e-learning practices in Palestine as an instance of the larger Arabic culture. This stream of research is currently receiving mounting attention, as e-learning systems and practices become a global issue, which crosses various cultures and boarders.

The paper relies on the experiences of the researcher, his observation and experience in teaching both online and traditional courses at university level. Focus group discussion and interviews were also employed to deepen understandings of various research issues.

This research proposes that domestic culture dimensions of collectivism and relationship-orientation of the Arabs greatly impact their appreciation of e-learning. Oral-interactivity and synchronous chatting were also basic drivers for Arab students to value e-learning. However, the need for structurization, and continuous management and follow up were found crucial for the success of these solutions among Arab learners.

This analysis presents concrete guidance for global firms in the domain of electronic learning and training to understand the role of the diverse cultural scope on e-learning. The guiding strategies stemmed out of this report can be applied in other Arabian countries, as they more or less have similar cultural norms and practices.

1 INTRODUCTION

This paper provides an explanation of how the Arab learners' cultural values influence the way they perceive and benefit from these technology educational solutions.

Electronic or E-learning which encompasses the extensive use of Information and Communication Technology (ICT) in education, is receiving mounting attention in all circles as most Internet accesses these days are turned into broadband which facilitates design, delivery and interaction with learning material, which makes these technologies more interactive, scalable, and effective.

However, it is to be stated that E-learning in its different flavors and settings are built to satisfy the western and developed society's development needs, and thereof, have a western cultural bias. This might make these educational solutions not fully compatible with other cultures, such as the Arabic culture.

It is quite obvious that habits and cultural norms that are perceived through traditional learning both inside and outside classrooms, which are sometimes termed as learning "naturally", will impact the way how learners perceive and view electronic and web based learning methods.

The paper will rely on agreed upon definition of culture and to use this definition to examine how this culture will impact e-learning. In particular, it will demonstrate how cultural factors interact with and influence students' learning and engagement in both synchronous and asynchronous learning modes.

The main goal of this paper is to raise awareness about the cultural factors that may affect E-learning and to provide guidance for courses and content developers for the needs and requirements of Arab learners.

In all societies, culture is strongly linked to national identity and ethnic foundations. Based on the prominent work of Hofstede (1980), the trend has been to think of national groups as having the same patterns of thought, action, and values.

In recent times, culture is viewed as an entity that crosses ethnic and national boundaries. Hence, according Branch (1993) to culture covers all patterns formed by religion, ethnicity, language, socio-economic status, profession, ideology, gender, and lifestyle. This definition of culture supports the impression that every individual and organization is both cultural and multicultural.

2 LITERATURE REVIEW

The impact of culture on education has its roots in traditional education before it extends its branches to electronic or Internet based learning. Teachers accommodations for students cultures within the same class and the struggle between teacher culture and student's culture is a subject of extensive research in education, (Moore, 2006). Moore reports on problems and difficulties evolve if the instructor's pedagogical values are not compatible with students' assumptions about how teaching should be done.

Building educational systems and practices on certain set of values, in a world of diverse context has its severe consequences on the learning processes and their outcomes. According to Gramsci (1971) this practice is stemmed out of a phenomenon he called "hegemony" which refers to a bunch of assumption of the dominant group or culture who view their values as common sense, or interests that serve for all. Several scientists have investigated the question of cultural hegemony in traditional learning, and many of them have proposed methods of incorporation of multiple cultures in education. Such theories include. Ladson-Billings, (1995) proposed the "culturally relevant pedagogy", while Gay (2000) developed the culturally responsive teaching". "Culturally sensitive instruction" was put forward by Boyer, (1993).

Zhao, Lei, Yan, Lai, and Tan (2005) classified the issues influencing the effectiveness of Electronic learning. They analyzed 423 empirical studies that compared face-to-face education to electronic learning. They came to conclude that electronic education is still a form of education, and the factors that impact the effectiveness of electronic education are more or less the factors that affect the effectiveness of traditional education.

Their findings clearly indicate that electronic learning is by no means exempt from the difficulties stemmed from cultural norms. Moore (2006) claimed that electronic environments is more vulnerable to cultural conflicts than traditional systems as both teachers and learners are participating in the educational processes from their native cultures, i.e. while stay situated physically and socially in the different cultures. This according to Moore will pose shift cultural challenges to higher level.

There exists considerable number of studies that treated cultural intervention with electronic learning. Thompson and Ku (2005) studied the interaction of Chinese students with online learning. The study revealed that Chinese students were less critical and narrow-minded in online chats than their US counterparts. Thompson and Ku referred this observation to the fact that Chinese culture is highly collective and feminine, which tends to respect group endeavors, agreement, affection, compassion and emotionality. Tu (2001) et. al (2000) also investigated Chinese online learners. They too stressed the significance of social domestic context and cultural norms and showed how they tend to rely on non-oral signs and cues in their interface with online courses.

Al-Harthi's (2005) investigated cultural interferences of Arab students studying in American universities. The researcher remarked that these students were rather afraid and nervous concerning their participating in online courses. The researcher associated this to their inability to act independently in their learning efforts, which reflects Arab culture's high uncertainty avoidance (Hofstede, 1991).

Shattuck (2005) investigated Asian and Middle Eastern students taking online courses delivered by an American university. They both found that cultural discrepancies hamper students' communication and success in online courses, producing a feeling of isolation, alienation, and conflict with the dominant educational culture at these universities.

Goodfellow, et al. (2001) studied the performance of non-English native students pursuing their education in UK. The researchers found that their difficulties with languages and their inability to use English professionally and other difficulties related to environment in UK greatly affected their academic achievement.

Morse (2003) found that the low context group highly appreciated the opportunity given to them by the online courses to participate in the discussion and to reflect on other people's opinions, which he termed as "outwardly oriented". On the other hand, he discovered that the high context participants are more "inwardly oriented," as they tended more to value the time afforded by online courses to think more about their own contributions. This study also revealed that students from high context cultures stressed that the lack of face-to-face communication hinders their ability to learn and to form social relationships, whereas low context students had not had any difficulties in the lack of face-to-face contact which impacted their learning abilities positively or negatively.

Biesenbach-Lucas (2003) studied the discrepancies in attitudes and behavior of American and non-American students, again at graduate level, in regards to Asynchronous discussions. None American participants expressed their satisfaction in regards to the system as it gives them opportunity to dig into issues at their own pace, and to understand issues from various angles which greatly improves their level of understanding of material much better than traditional and face to face lecturing. The same study revealed that None American were reluctant and less enthusiast in expressing their opinion and showing disagreement, they may consider challenging and criticizing other's ideas culturally inappropriate, and/or they may "not know how to express disagreement appropriately in English.

Anakwe and Christensen (1999) studied the influence of individualism and collectivism on online education. The study concluded that distance and online learning is more compatible with cultures that tend to have high individualism attitudes that collectivism. Tapanes, et al. (2009), investigated the same theme through collecting data from 40 online students from two American universities. The study found that students from collectivistic cultures to be less motivated to participate in online courses than those from individualistic cultures.

3 RESEARCH METHODOLOGY

Qualitative research methodologies are adopted in this research, as the research aims to analyze and understand attitudes and behaviors on performing and practicing certain set of actions, namely electronic and distance learning. The research team believes that qualitative research fits better with the research question of this paper as the research theme is exploratory in nature, and needs to go deeper into the issue of interest and explore nuances related to the problem at hand.

The paper relies heavily on the technique of participant observation, which is considered to have some strength, particularly in organizational research. Participant observation in organizational research tends to investigate core issues from within inside the organization. The arguments used by many organizational sciences scholars, backing this research approach list the use of personal involvement, expertise, and deep knowledge of issue at hand of the research question, Evered and Louis (2001).

Iacono, Brown, and Holtham, (2009) asserts that better knowledge can be generated by functioning within the organization. Sometimes participant observation arises from an ongoing working situation, as is the case when the observer is an industry practitioner [ibid]. It involves participating in a situation, while, at the same time, recording what is being observed. It offers the chance to obtain unique insights into the organization or social group.

This study is set to investigate students' experiences in electronic learning, and how their practices are stemmed out of their domestic cultures. The data sets of this study are collected throughout the years of experience the investigators have undergone in teaching and observing students through 3 years of time, the period of the involvement of the investigator with the e-learning at the local university where he teaches. The collected data comprised of the cumulated experience of the phenomena, including thinking, believing, perceiving, observing – and the things to which these acts are related such as ideas or material objects. According to Merriam and Simpson,(1995),these are eligible source of data sets for such kind of research.

The researcher was an observer during the course, collecting qualitative data through the observation of activities and engagement and also carrying out a focus group in the final week of the course to gain a deeper understanding of particular issues related to the active participation of learners.

In addition to observations, Semi-structured interviews were arranged and employed to collect data. Throughout the interviews participants were allowed to reconstruct their experience within the context in which it occurs, and to reflect on the meaning the experience holds for him/her.

This study focuses on students from the Northern Part of West Bank, Palestine, pursuing their education at the Arab American University, a university adopting the American teaching style, and launching some initiatives in Electronic and distance learning as support for traditional learning. The sample population is a homogeneous one with the same cultural basis such as languages, religion, history, norms and values. They even share many similarities in their socio-economic and political structure. Participants in the research have taken as a minimum one online course or some components of their courses are done online. The sample population consisted of more than 200 students.

4 MAIN FINDINGS

Throughout the research period, the researcher continue observing students behavior in relation to their learning practices in the e-learning courses, and try to categorize their behavior in regards to their views and utilization of the available learning resources. The remarks compiled throughout the observations are categorized into themes so that their impact on the overall learning processes is easily assessed.

The main findings of the research will be summarized as students learning habits and then see how they can affect their interaction with electronic learning.

1- Students in general tend to be oral-based, as they enjoy communicating their knowledge orally, i.e. they highly value the spoken language. Students enjoy listening and speaking, this was very clearly indicated by the level of their involvement when oral interaction was involved in the electronic course. The majority of students (over 80%) who participated in the study revealed that they prefer oral presentation over textual or documental information.

2- Participating students tend to be very social and in favorite of collaborative and collective activities much more than self or individual efforts. Students showed high level of enthusiasm when there are group activities. That was clearly indicated by their tendencies towards participating in synchronous group discussion over the E-learning portal.

3- Students are very keen to synthesize personal relationship with instructor and with other course participants, and they consider this as very crucial for them to enjoy learning the material and benefit the most from it. The more students have lively and close relationship with teacher the more then tend to put efforts and to spend more time with the Electronic courses.

4- Students are always in favorite of high structurization in their teaching endeavors. Structurization, includes specifying what exactly to study, how much material is required, setting up times and deadlines for assignments and exams, and specifying the rewarding mechanism and grading policies beforehand. This issue has very much to do with the fact that students should be forced to participate in the learning activities, and not to give them the feeling that their obligations are relaxed via the e-learning system. Majority of students participated in the study are not independent learners, as they need continuous guidance and encouragement throughout their learning processes. Most of them feel lost in the flexible nature of online learning, and are desperately seeking some kind of support or structure.

5- Students are addicted to the teacher-centered approach of learning. Even in an online courses, students requires some kind of higher authority, with better knowledge and experience to guide them through the learning processes. This phenomena has to do with society hierarchy and structure which requires some kind external promoter for their actions deeds.

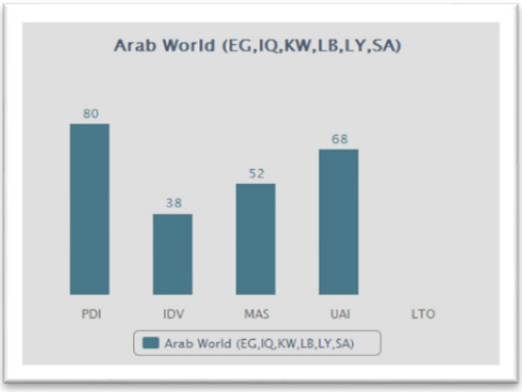

Figure 1: Hofstade Arabic cultural dimensions (PDI: Power distance, IDV: Individualism, MAS: Masculinity / Femininity, UAI: Uncertainty avoidance, LTO: Long term orientation.

Source: http://geert-hofstede.com/arab-world-egiqkwlblysa.html

4.1 Impact of Learning Habits on e-Learning

Collectivism and socialism of students in this area and Arab students in general seem to induce students to work together more than students in the Western societies. This is why chats (both voice and text) in our courses are much more popular than the discussion forum. Students ability to use online course to form a stance together, or a debatable issue is much more attractive and efficient than forming a personal opinion alone. This trend can be easily explained by the fact that Arab culture tends to be more oral and collectivists. This means that in general they tend not to like the distance aspect of the e-learning approach, at the same time they found it attractive because of the interactive and collective nature of the activities. The student's culture appreciates close association and prefers visual and people-centered, interactions.

Throughout my experience with the students, it was quite clear that they prefer to do their assignments and tasks in real-time. And they tend to share their ideas with their colleagues when possible and not to form an individual opinion, especially when there is a debatable issue, with which it is not easily possible to formulate a stance for.

Online collaboration on projects requires them to work at the same time on the tasks, with a kind of group thinking, and online real time discussion. That is to say collaboration on tasks where students have to build on each other's work has not been so successful. This was quite clearly pronounced by the preferable synchronous chats by the students over the wiki facility provided by Moodle.

This observation is crucial in the way of assigning online tasks for students. Online assignments should promote online synchronous discussion as much as possible. This will allow students to learn from each others synergistically, and allow them to generate and synthesize new knowledge. The assignment that promotes discussion among students is the one which does not imply division of tasks into sub tasks for students, but rather the one where all students are asked to work on the same task at the same time.

Interaction and networking are strongly rooted in the students' Arabic culture, this means that students will like the course and be attached to it the more it promotes interaction and communication. As one student has put it; "it is much more attractive to participate in the synchronized chat than to write in the Wiki. Via chats teacher and all students see your participation, and they may like it, which give me a sense of pride and self fulfillment"

Students inclined to have a collective conclusion or opinion, stemmed out of their strong incline towards collectivism, an culture norm which opposes individualism, see figure (1) above. This is still another indication of the direct interference of the cultural pillars with students learning style.

Another very critical issue raised by participant students has to do with their willingness to participate in online over face-to-face discussion. Many students, especially female students expressed their satisfaction and convenience with the online chatting and discussion, as it does not involve facial and in person confrontations. For female students and for significant percentage of male students, face to face argumentation and disagreement would lead to embarrassment, emotional and psychological one. "Over the web, you don't real feel it, even if it is expressed in writing, you parley feel it, and in most cases it passes with only few people feel it" Areen has commented. The Arabian society is a place where opinions do matter a lot, and the person's position is mainly a reflection of his or her opinion over some issue.

Many students have talked about the opportunity online learning give them to talk in public with no teacher presence. They expressed relieve over the ability to express opinion without the instructor presence. These stances, are related to the fact that Arabian society is hierarchical, and respect of elder people is a quite common practice.

5 CONCLUSIONS

This paper is arguing that cultural norms are crucial factors to be taken into account when e-learning material are designed and presented to learners with various cultural settings. The paper tested the interaction of learners of one Palestinian university throughout years of teaching using both traditional and electronic means.

The paper has demonstrated that socialization and collective activities are crucial aspects to be taken into account when designing electronic learning for Arab students. Arab students, as the cultural norms dictate tend to interact and respond with higher enthusiasm with collective and live activities. Students are inspired by their colleagues at the other end talking and text interacting in a synchronous than in asynchronous mode. Arab students are found to prefer oral than textual interaction via the electronic learning systems.

The research project is at its beginning, and more cultural components like power distance, sense of time, the balance between image and meaning, and the influence of context, will be analyzed and integrated in future research activities and publications.

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REENACT: Learning about Historical Battles and Wars through Augmented Reality and Role Playing
An EXPERIMEDIA Experiment

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Keywords: Future Internet Research and Experimentation, Technology-enhanced Learning, Augmented Reality.

Abstract: This paper presents one proposal to engage groups of people into immersive collective experiences to learn about a certain historical battle or war, from the point of view of reenactors and historians. The participants will be equipped with tactile mobile devices that interact with an augmented reality platform and an online environment for the orchestration of distributed live games, provided by the technological facility that is being developed within the EXPERIMEDIA FP7 project. We describe the implementation and experimentation plans, including a discussion of the indicators we will be measuring to assess *Quality of Service*, *Quality of Experience* and *Quality of Community*.

1 INTRODUCTION

Human History has been shaped by the outcomes of countless battles and wars. Unfortunately, the classical pedagogy of these events puts them down as occasional events that just happen, that involve two sides (often appearing as the good and the evil forces) and that apparently end fortuitously, as by tossing a coin. This approach neglects many facts about the reasons for the battles, alliances and supporters, why things went on the way they did, what were the winning or losing choices, what were the consequences in the short, medium and long terms, etc. As a result, the general awareness of History in our society is rather partial and deficient, and the students end up with little more that a collection of dates and a vague idea of who defeated who.

Novel technologies provide powerful means to make things better and more interesting. Smartphones and tablets have already been around for some time (Moon et al., 2010; Akkerman et al., 2009; Sala et al., 2011; Lohr, 2011), just like social networking (Arends et al., 2012; Agarwala et al., 2012; Díaz et al., 2012), videogames for learning (Charsky and Ressler, 2011; Watson et al., 2011; Froschauer et al., 2012) and even location-based and virtual reality educational tools (Tosatto and Gribaudo, 2009; Jacobson et al., 2009). Combining these elements and going one step further, we present in this paper a new approach (called REENACT) that brings augmented reality (AR) technologies into History learning. The aim is to engage groups of people into immersive collective experiences that will make them learn about the prelude, the course and the aftermath of battles and wars with the aid of tactile mobile devices, repositories of multimedia contents, an advanced technological facility and remote experts. We present the details of the proposal in Section 2, followed by a description of the implementation plan in Section 3. The experimentation plan is presented in Section 4, including a discussion of the indicators we will be measuring to evaluate *Quality of Service* (QoS), *Quality of Experience* (QoE) and *Quality of Community* (QoC). Conclusions about the potential value of the proposal for different stakeholders are given in Section 5.

2 THE REENACT APPROACH

The REENACT experiences will be organised in three stages, that give the participants the possibilities of learning about one event from inside, as reenactors, and from outside, as historians. Next, we will briefly explain these stages with examples borrowed from the scenario of the Battle of Thermopylae, which is the first event we will experiment with. This event is quite popular as a symbol of courage against overwhelming odds, but it is not really well understood due to non-rigorous treatment in movies and comics. Fortunately, the details reported by Herodotus and other historians provide sufficient scenes to yield both a didactic and enlightening experience to explain such facts as the advantages of training, equipment, and good use of terrain as force multipliers.

2.1 The Reenactment Stage

Stage 1 is about involving groups of people in the reenactment of battles. They will be moving around in a room with a number of QR codes on the floor or on the walls, where they will spend 15–20 minutes immersed in a multiplayer role-playing game with an AR vision provided by tactile mobile devices. The QR codes serve to identify zones in the reenactment space, as needed to enable different actions at different places over time. Figure 1 depicts the zones defined for the Battle of Thermopylae over a distorted map of Greece, including Asia Minor (where the Persians came from to conquer the Greek city-states), Sparta and Thessaly (home of some of the main characters), the settlements of the Persian and Greek armies at Thermopylae, the sky of Elysium (for the Greeks who die and do not get new roles), the Tartarus (the Greek underworld) and the Garothman (the heaven of Zoroastrianism).

Figure 1: Zones for the reenactment room of the Battle of Thermopylae.

After watching a brief projection explaining the historical context of the conflict, the participants will be lent one tablet, take up one role in the battle and start playing. Using the tablet, each participant will be able to visualise his/her position in the scenery, mapping the zones to real locations on a satellite view that may be overlaid with historical maps as in Figure 2. Additionally, the tablet will be offering the actions each participant may make at any given moment: to advance on a certain stand, to retreat, to fight one way or another, to surrender or not, etc. The choice of possible actions will be a function of each individual's choices, choices made by other characters in the past or decisions made collectively by voting, as determined by a script of the event.

At certain points, the participants will enjoy 360° views of the scenery and 3D contents linked to the markers laid on the floor or on the walls. Likewise, to enhance the feeling of a collective experience, one laptop can be put to use any big screens or projection boards available in the reenactment room to display the visualisation of the scenario of the battle, along with video footage that may serve to illustrate what is going on, and even pictures or textual comments coming from the reenactors' devices. If available, loudspeakers will play accompaniment music and sound effects for further immersion. These features may enhance the educational aspect too, as proved in (Fassbender et al., 2012). We will also exploit the tablets to make the reenactment a playful experience, for example, to play sounds when the device becomes a sword or to allow shooting arrows by dragging a slingshot.

2.2 The Replay Stage

Once the recreation of the battle has finished, the participants will be taken to a projection room to analyse what has been happening. They have already lived the battle from inside, with a very partial vision, and now it is turn to learn more by watching things from outside, and to see how their recreation compares to the real historic events. This second stage of the REENACT experiences will be driven by one expert, who may be physically present at the projection room or appearing on the screen from a remote location. The expert will rely on a record of the movements and actions of each participant during the reenactment. Combining this record with the script of the battle, the expert will be able to identify specific situations lived by the reenactors that could serve to explain important facts about the course of the fights (e.g. to illustrate the technological superiority of one of the opponents, the war tactics employed, etc).

The important point of the replay stage is to relate the reenactors' experiences with the historical

Figure 2: A view of the Thermopylae area with a historical map overlaid.

facts, which should help them to realise and memorise facts that usually go unnoticed in traditional History teaching. Therefore, the expert must devote some time to explaining what aspects of the reenactment diverge from the real facts, either because the scripts make some allowances or because the participants have made the opposite of the real characters' decisions. Also, the expert may choose to run a collective quiz game with multiple-choice questions about the prelude and the course of the event. This may be a qualifying game (the one who misses an answer is eliminated) or a cumulative one (the one who gets the greatest number of correct answers, wins). Typically, there will be only one correct answer, while at least one other option could make sense and at least one would be ridiculous, like in the following example:

- *What type of bridge did the Persians build to cross the Hellespont?*

  1. *Two 1.3 km pontoon bridges. (TRUE)*
  2. *A Roman stone bridge. (FALSE)*
  3. *A double-decked cast iron bridge. (FALSE)*
  4. *A suspension bridge. (FALSE)*

There will also be questions in which all the answers are correct, just seeing one fact from different perspectives, like:

- *What was the year of the Battle of Thermopylae?*

  1. *The 4th year of the 74th Olympiad by the Attic calendar. (TRUE)*
  2. *Year 274* ab urbe condita*. (TRUE)*
  3. *Year 2157 by the Chinese calendar. (TRUE)*
  4. *Year 23 by the Achaemenid calendar. (TRUE)*

Finally, there may be features for pure entertainment like awards to the best soldiers, rankings of participants ordered by how long they have survived, galleries of user-generated pictures, etc.

2.3 The Debate Stage

Finally, in stage 3 (debate), the expert will drive a collective brainstorming about the consequences of the conflict in the short, medium and long terms, wondering what might have been different in History if things had happened differently. For example, considering the Battle of Thermopylae (which was not really decisive in the broader context of the Greco-Persian wars), the topics for debate will include the following:

- *Would there be fewer ruins in Athens today if King Leonidas had stopped the Persians' advance? Would the Parthenon ever have been built?*
- *Would the Persians have conquered the whole of Europe? And what else? Who would have stopped them: the Macedons led by Alexander the Great the next century, the Carthaginians a little bit later, the Celts, the Vikings, ...?*
- *Would science have developed better or worse? Would the Middle Ages still occur? And the industrial revolution?*
- *Would the Europeans have discovered America, or someone from America have crossed the Atlantic Ocean the other way before? If so, who?*
- *What would our languages sound like? What about sports and music?*
- *Would Zoroastrianism get to be the predominant religion in the world? Would we ever have heard of Christianism or Islam?*

During the debate stage, the projection screen will become a dynamic big board to display comments posted by the visitors, which can be rearranged by the expert. At any time, the expert will be able to choose multimedia contents to illustrate the different points that are raised. Participants will type their comments using the tactile mobile devices, and, if chosen by the expert, they will have the possibility to explain their ideas or viewpoints to the whole audience in an audio- or video-call. Some arguments can be voted upon, or socially rated as "*possible*" or "*impossible*", "*likely*" or "*not likely*", "*interesting*", "*absurd*", "*original*", so that the most active visitors get some kind of recognition. Again, there may be quiz games to appraise the participants' understanding of the importance and impact of the battle.

3 IMPLEMENTATION PLAN

The REENACT proposal is being developed on top of the Future Media Internet (FMI) technological facility provided by the EXPERIMEDIA FP7 project[1]. As explained in (Salama et al., 2012), the technologies that reside in the EXPERIMEDIA facility have been encapsulated into four components under common type of content:

- The *Experiment Content Component* (ECC) monitors, derives experimental data from, and manages the other components, taking control of installation, deployment at the experimentation venues, running and termination.
- The *Social Content Component* (SCC) gathers and manages data that is generated on social networking sites during the course of an experiment. Internally, it provides access to different social networks (giving read access and publishing capabilities) and also communicates social network monitoring metrics to the ECC.
- The *AudioVisual Content Component* (AVCC) provides services related to the management and delivery of audiovisual contents, including acquisition from a media producer, adaptation and distribution to different platforms, live edition and realisation, and data and metadata synchronization.
- The *Pervasive Content Component* (PCC) provides means to track the users' locations as a means by which AR content can be selected for delivery and user-generated data can be mapped to a spatial location. It also hosts an augmented reality platform and an online environment for the orchestration of distributed live games.

The REENACT experiences will be delivered by a software system comprising one server and three main interfaces:

- The *REENACT server* will centralise access to pre-recorded contents and live streaming through the AVCC, to store the records of events raised during the reenactments and to control what is displayed on the different areas of the projection screen during the replay and debate stages. Besides, it will provide a repository to store the static images and the text documents that may be used for illustration purposes at any time.
- The *reenactors' front-end* will be provided by an Android application that delivers the interactions envisaged for the participants during the reenactment, replay and debate stages. This application relies on the PCC to render the AR vision of the reenactments on the participants' devices, and on the SCC to support messaging, ratings and so on during the replay and debate. It also interacts with the AVCC to control the flows of text, images and audio entering and leaving each device.
- The *expert's front-end* will be a web application providing the controls needed to conduct the replay and debate stages. The application will interact with the AVCC to allow the expert to join from a remote location and to browse multimedia contents. His/her participation will be realised through the SCC as for the other participants, though including means to manage the arguments raised during the debate, including features of real-time parsing (e.g. to highlight key words) and filtering of text messages in cases of foul language or disrespectful/offending comments.
- Finally, the *administrator's front-end* will provide the interfaces needed to supervise the operation of the rest of the elements during the REENACT experiences, including manual control over the orchestration of events during the reenactment stage and the gathering of information for later evaluation in cooperation with the ECC.

4 EXPERIMENTATION PLAN

The scenario of the Battle of Thermopylae is being developed in collaboration with the Foundation of the Hellenic World (henceforth, FHW), a not-for-profit cultural institution based in Athens that boasts a unique technological infrastructure, including a dome-shaped room that displays 3D contents rendered in real time. The FHW is providing support from expert historians to develop historically rigorous scripts for the reenactments and sets of questions and topics for replays and debates. Besides, their virtual reality department is contributing 3D models for the

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[1] http://www.experimedia.eu/

AR features as well as some pictures and audio/video footage to put into the content repositories.

The core of our experimentation will be done during the summer of 2013 in the Hellenic Cosmos (the venue provided by the FHW in Athens), but this will be supplemented with trials in the University of Vigo, both *ex ante* (to get early feedback and fix defects in the software or in the experiment design) and *ex post* (to gather further evidence for the evaluation or to assess questions that remain unanswered). Participants will be recruited from among the communities of students, professors, researchers and other staff of the University of Peloponnese and the University of Vigo.

During the experimentation sessions, the REENACT software will be feeding data into the ECC, that will be processed later to evaluate a number of QoS, QoE and QoC parameters. To begin with, QoS data will consider aspects like the the responsiveness of the communication with the different pieces of software lodged remotely in the EXPERIMEDIA facility, including the quality and the latency of the pre-recorded videos served to the tablets and the projection screen, the quality, latency and synchronization of the audio and video feeds from the expert's webcam, and the latencies in the communication with the "*Live games*" element of the PCC during the reenactment stage.

Regarding QoE, the REENACT system will keep track of all the movements and actions of the participants during the reenactments, and also of their interactions during the replay and debate stages (including stats about how and when the participants use the different features and interfaces). Additionally, the mobile application will provide brief questionnaires to gather opinions about the REENACT approach and to rate different features of the experience: educational value, level of entertainment, convenience of the interfaces, quality and completeness of the contents, preferences for certain types of contents, etc. Those ratings will be matched against anonymous information about the participants' educational background and interest in specific topics.

Halfway between quantitative and qualitative, the voting and quiz games offered during the replay and debate stages will be used as sources of information about the participants' level of engagement and learning about the historical events. As a research question, it will be checked whether any of the aforementioned parameters depends on the roles played by the participants during the reenactment stage, since it might happen that the QoE measurements are better for someone who has played a main role (say, King Xerxes in the Battle of Thermopylae) than for someone who has played a secondary role (e.g. a Persian infantryman), or maybe that differences appear between winning and losing sides.

Finally, QoC measurements will look at quantitative and qualitative aspects of the community of people that participate in a REENACT session. To this aim, we will primarily look at the interactions among the participants during the replay and debate stages, e.g. counting the number of ratings and analyzing the length, mood and depth of the comments they exchange using their tactile mobile devices. Special attention will be paid to what happens among people who did not know each other before, for which they will all be asked to tick out the nicknames of their acquaintances right before starting the reenactment stage. Thus, it will be possible to address questions like whether strangers keep distances during the reenactment, whether they comment on the others' arguments, or whether there is any apparent bias in the ratings given to acquaintances and strangers.

Some subjective input from the administrators will also be sought over the different experimentation sessions, to rate the general mood of the participants during the reenactment stage: *were they engaged? Were they apparently bored or having fun? Did they dare to talk aloud when required by their roles?*

5 CONCLUSIONS

Our experimentation is intended to appraise the value impact of the REENACT proposal for museums as well as primary and secondary schools. The data gathered about the aforementioned QoS metrics are mainly relevant to the construction of the EXPERIMEDIA facility, but the QoE and QoC data will be used to assess the truth of the following claims:

- Museum visitors or students will enjoy new edutainment experiences aimed at improving the understanding of historic events, with an opportunity of interacting with one another and with geographically distributed experts.
- Museum guides and educators will be able to participate in a new type of collective experience, supplementing the expertise and knowledge provided by the experts in replays and debates.
- Expert historians will be able to offer their services to collaborate in new pedagogical experiences, interacting more closely than ever before with people interested in knowing more about major historical events.
- Content creators/providers will find an additional outlet for the multimedia contents they produce, which will be usable to provide historically-meaningful explanations to the situations arisen

during the reenactments and to the arguments raised during the debates.

- Last but not least, the experimenters (ourselves) will draw useful conclusions about the ease of use of the game-like interfaces provided for the reenactment, the didactic value of the different stages, the interest of engaging in social discussions, etc. This valuable insight will serve to enhance our ongoing research activities in the area of information services, which deal with various flavours of technology-enhanced distance learning.

Commercial exploitation of the REENACT solution could happen through the selling of the technology, its implantation in the venues, training courses for educators, implementation of reenactment scripts and production of multimedia contents.

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FouSE: An Android Tool to Help in the Teaching of Fourier Series Expansions in Undergraduate Education

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Abstract: This paper presents an Android application to help in the teaching of Fourier series expansions in undergraduate Electrical Engineering. Consequently, it discusses the teaching of Fourier series concepts in connection with undergraduate Electrical Engineering education; some of the basic Fourier series theory is briefly reviewed. The presented Android application has been found useful in this context. As expected, the application has an easy-to-use, friendly interface, and can be viewed as a tool to help undergraduate students test and assess the Fourier series expansions on a typical set of signals, whose analytical Fourier series coefficients were found during the theoretical lectures. Additionally, some of its main characteristics include the ability for the students to control the total approximation error and the number of terms/harmonics used in the expansion.

1 INTRODUCTION

Among the most important studied topics in undergraduate Electrical Engineering education are Fourier series expansions (and Fourier theory in general). As a natural consequence, a large fraction of the signal processing and also mathematical literature is devoted to the teaching of Fourier series expansions (and Fourier theory in general). Having a solid understanding on the most basic principles of Fourier series expansions is of utmost importance, especially when dealing with problems which fall, for example, in the scope of multidimensional signal reconstruction, and which includes sampling theory, interpolation, extrapolation, signal and image conditioning, interactive image repair, deconvolution and other inverse problems, reconstruction in tomography, filter design, and much more.

Moreover, Clark Quinn (2000, http://www.linezine.com/2.1/features/cqmmwiyp.htm) defines Mobile Learning (*mLearning*) as "*eLearning* through mobile computational devices: Palms, Windows CE machines, even your digital cell phone". Harris, (Harris, 2001), defines mLearning as the intersection point between mobile computing and eLearning, producing a learning experience anytime and anywhere. mLearning is characterized by the capacity of accessing learning resources from anywhere, at any time, with high search capacities, high interaction, high support for an effective learning and a constant valorization based on the performance. So, one can see mLearning as an extension of eLearning, but characterized by its capacity of being independent in terms of space and time. The idea is to have small devices capable of being linked to the net, easy data input, and the ability to display high resolution images and also (very) good sound capacities. Hence, mLearning can benefit from all advantages of the web added to mobile technologies. In summary, we may say that mLearning relies on the utilization of mobile technologies at the service of the processes associated with teaching and learning. There is a huge number of mobile applications that have been recently developed with the aim of being used within the mLearning context. For example, in (Holzinger et al., 2012) the authors discuss the development of smart adaptive user interfaces for mobile e-Business applications, and the lessons learned. In (Mujacic et al., 2012), Modelling, Design, Development and Evaluation of a Hypervideo Application for Digital Systems Teaching is presented and discussed. The process of life-long learning, in conjunction with three different models for mobile/ubiquitous applications is discussed in (Holzinger et al., 2010).

We believe that a first course focusing on Fourier series expansions would gratefully benefit from the fact of having a tool that let students test and assess Fourier series expansions, anytime and anywhere they want, and using their own Android powered devices (for example, during the lunch time conversations, using their own smartphones and tablets). Moreover, this application can be a welcome addition to the background of Electrical Engineering students, especially to those interested in telecommunications, information theory, or signal/ image processing in general.

Solving problems while experimenting and comparing the available algorithms is of fundamental importance in the learning process. The application presented in this paper was aimed at helping students do that.

Additionally, we felt a need for tools that could be easily used inside or outside the classroom, easily updated and/or maintained, and that the students could use with their own smartphones/tablets.
The development of the type of application proposed and described here is additionally justified by the increasing number of available mobile devices with the required functionalities and capacities, described above, and the number of students using them.

We believe that a small introduction to Fourier series will help to clarify the ideas that lead to the development of the application. The next section is dedicated to this.

2 FOURIER SERIES DEFINITION

A signal (function) $s(t)$ is said to have period T if $s(t+T) = s(t)$ for all t. If the signal is piecewise continuous in a period, with finitely many points of discontinuity and finitely many maxima or minima (also known as Dirichlet's conditions), then the Fourier series converges to $(s(t+)+s(t-))/2$ (see, for example (Tolstov, 1976), for details on existence and convergence of the Fourier series). In that case, the Fourier series of the signal $s(t)$ is given by

$$s(t) = A_0 + \sum_{n=1}^{\infty} A_n \cos(n\omega_0 t) + \sum_{n=1}^{\infty} B_n \sin(n\omega_0 t),$$

with

$$A_0 = \frac{1}{T}\int_{-\frac{T}{2}}^{+\frac{T}{2}} s(t)dt,$$

$$A_n = \frac{2}{T}\int_{-\frac{T}{2}}^{+\frac{T}{2}} s(t)\cos(n\omega_0 t)dt$$

and

$$B_n = \frac{2}{T}\int_{-\frac{T}{2}}^{+\frac{T}{2}} s(t)\sin(n\omega_0 t)dt,$$

where $\omega_0 = 2\pi f$, and $f = \frac{1}{T}$, the fundamental frequency of $s(t)$.
Fourier series may come in different flavors and tastes. Here, we are interested in the different connections and interpretations it may have from a future electrical engineer point of view. For example, see chapter 5 of (Brigham, 1974) or (Ambardar, 1995) for the connections between the complex and trigonometric forms of the Fourier series, the Fourier series as a special case of the Fourier integral, waveform sampling, and sampling theorems.

2.1 Fourier Series of Even, Odd and Half-wave Symmetric Signals

The Fourier series expansion of an even signal $s_e(t)$ with the period of T does not involve the terms with sin and has the form

$$s_e(t) = A_0 + \sum_{n=1}^{\infty} A_n \cos(n\omega_0 t),$$

where the Fourier coefficients are given by

$$A_0 = \frac{2}{T}\int_{0}^{+\frac{T}{2}} s_e(t)dt,$$

and

$$A_n = \frac{4}{T}\int_{0}^{+\frac{T}{2}} s_e(t)\cos(n\omega_0 t)dt.$$

Accordingly, the Fourier series expansion of an odd T-periodic signal $s_o(t)$ consists of sine terms only and has the form

$$s_o(t) = \sum_{n=1}^{\infty} B_n \sin(n\omega_0 t),$$

where the coefficients B_n are

$$B_n = \frac{4}{T}\int_{0}^{+\frac{T}{2}} s_o(t)\sin(n\omega_0 t)dt.$$

A T-periodic signal $s_h(t)$ is said to have half-wave symmetry if $s_h(t \pm \frac{T}{2}) = -s_h(t)$. In that case, the Fourier series expansion coefficients will be

$$A_0 = 0,$$

$$A_n = \begin{cases} 0, & n \text{ even}, \\ \frac{4}{T}\int_0^{+\frac{T}{2}} s_h(t)\cos(n\omega_0 t)dt, & n \text{ odd}, \end{cases}$$

and

$$B_n = \begin{cases} 0, & n \text{ even}, \\ \frac{4}{T}\int_0^{+\frac{T}{2}} s_h(t)\sin(n\omega_0 t)dt, & n \text{ odd}. \end{cases}$$

2.2 A Typical Example—Square Wave

The next example shows a typical calculation of the Fourier series expansion coefficients, that we usually solve during the theoretical-practical lessons.
Let the periodic signal $s(t)$ be defined by

$$s(t) = \begin{cases} -1, & -2 < t < -1, \\ 1, & -1 < t < 1, \\ -1, & 1 < t < 2. \end{cases} \tag{1}$$

Typically, to find the coefficients of its Fourier series expansion we begin by plotting the signal, like the one presented in figure 1. From this figure (or from equation 1) we can easily find that the period is $T = 4$, leading to $\omega_0 = 2\pi/T = \pi/2$, and that $s(t) = -s(t)$, leading to $B_n = 0$. Additionally, we may also note that $s(t + \frac{T}{2}) = -s(t)$ (half-wave symmetry), leading to $A_n = 0$ for all n even. In conclusion, we only need to find the coefficients A_n for n odd, and so the Fourier series expansion will be of the form

$$s(t) = \sum_{\substack{n=1 \\ n \text{ odd}}}^{\infty} A_n \cos(n\frac{\pi}{2}t).$$

By the definition above,

$$\begin{aligned} A_n &= \frac{4}{T}\int_0^{+\frac{T}{2}} s(t)\cos(n\omega_0 t)dt, \\ &= \frac{4}{T}\left\{\int_0^1 \cos(n\omega_0 t)dt + \int_1^2 -\cos(n\omega_0 t)dt\right\}, \\ &= \frac{4}{T}\left\{\left[\frac{\sin(n\omega_0 t)}{n\omega_0}\right]_0^1 - \left[\frac{\sin(n\omega_0 t)}{n\omega_0}\right]_1^2\right\}, \\ &= \frac{4}{\frac{2\pi}{\omega_0} n\omega_0}\left[\sin(n\frac{\pi}{2}) - \sin(n\pi) + \sin(n\frac{\pi}{2})\right], \\ &= \frac{4}{2n\pi}\left[2\sin(n\frac{\pi}{2})\right], \end{aligned}$$

i.e.,

$$A_n = \begin{cases} -\frac{4}{n\pi}, & n = 3, 7, 11, \cdots, \\ \frac{4}{n\pi}, & n = 1, 5, 9, \cdots. \end{cases}$$

Note that the signal plotted in figure 1 and the corresponding expansion coefficients are the same used in the "square"-like wave form used in the available signals of the application (also illustrated in figure 3).

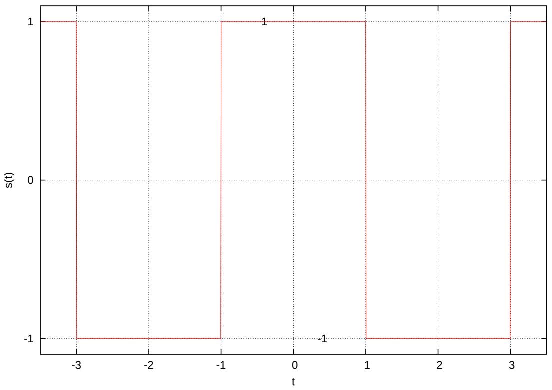


Figure 1: Plot of the square-like wave signal defined by equation 1.

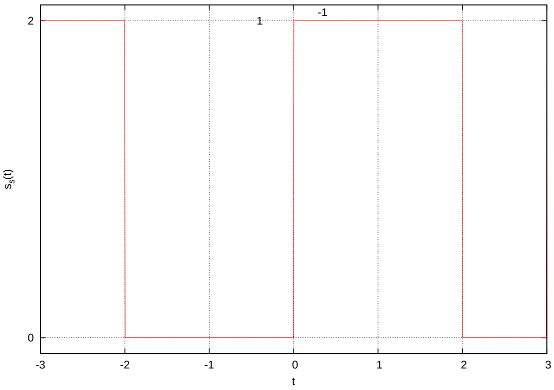


Figure 2: Result of shifting and translating by one the signal presented in equation 1.

Now, suppose that we shift the signal up and translate it right by one. The resulting signal, $s_s(t)$, is presented in figure 2. As a consequence, the signal will no longer be even, and will also lose its half-wave symmetry. A common mistake our students sometimes do is to assume that the translation of the signal converts it into an odd one, but the shift up also removes this symmetry (despite of the signal shape, which still is a square-like one). In this particular case the new coefficients will be

$$\begin{aligned} A_0 &= 1, \\ A_n &= 0, \\ B_n &= \frac{8}{n\pi}, \quad n \text{ odd}. \end{aligned}$$

This means that

$$\begin{aligned} s_s(t) &= 1 + \sum_{\substack{n=1 \\ n \text{ odd}}}^{\infty} \frac{8}{n\pi}\sin(n\frac{\pi}{2}t), \\ &= 1 + \frac{8}{\pi}\sin(\frac{\pi}{2}t) + \frac{8}{3\pi}\sin(\frac{3\pi}{2}t) + \cdots. \end{aligned}$$

This type of manipulations (translations and shifts) are made so the students can gain some insight on the changes introduced in the coefficients of the Fourier series expansion, and actually realize that the new values of the coefficients may become very different.

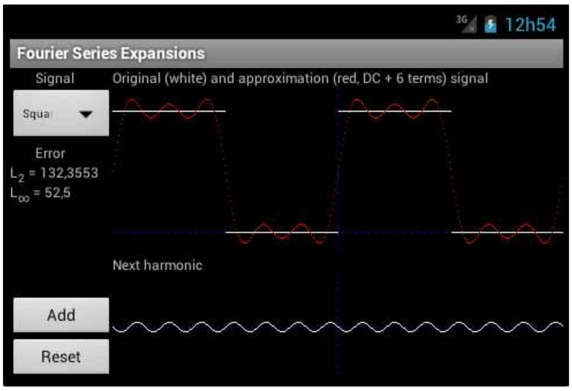
3 THE APPLICATION

The Android application, named "FouSE—Fourier Series Expansions", is freely available for download from "Google Play" (www.google.com). Android was our first choice, because the majority of our students have Android powered devices; still, we want to produce an iOS equivalent application. No particular concerns have directed the design of the user interface, besides the basic and obvious ones, and the major guidelines, as discussed for example in (Holzinger et al., 2012; Mujacic et al., 2012). Figure 3 shows a screenshot of the application. When no signal is selected, the spinner on the upper left corner will show the word "none" and the plotting spaces of the original and approximation signals, as well as the next harmonic plot, will be empty, because they have nothing to show.

The user interaction with the application is very straightforward. The first thing a user must do is to choose a signal from the list (by pressing the spinner below the text "Signal"). Then, by simply pressing the "Add" button, the user refines the approximation to the desired accuracy.

The list of available signals include:

- Sawtooth;
- $|\sin|$ (full wave rectified);
- Half sin (half wave rectified);
- Square;
- Triangle;
- Parabolic (t^2).



Error
L_2 = 132,3553
L_∞ = 52,5

Figure 3: Fourier series expansion of a square-like wave: DC term plus 6 harmonics.

The "control" section of the interface is placed on the left side of the screen. As seen above, the spinner below the word "Signal" is used to choose the signal to approximate. Once a signal is chosen, more information and control buttons will be visible. The error, over a period, of the approximation is presented using two different metrics:

- $L_2 = \sqrt{\sum_{i=1}^{N}(\text{signal}_i - \text{approximation}_i)^2}$;
- $L_\infty = \max_i |\text{signal}_i - \text{approximation}_i|$.

The "Add" button is used to add the next term (the signal presented next to this button and below the text "Next harmonic") to the approximation signal. The "Reset" button restarts the approximation.

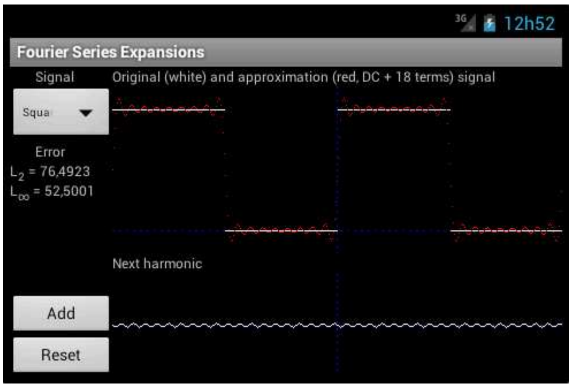
The upper right side of the screen presents two signals plots and one text message:

- the original signal plot (in white);
- the current approximation signal plot (in red);
- the number of terms used in the current approximation (DC term, plus harmonics, if any).

Every time the "Add" button is pressed, the current harmonic plotted below the text "Next harmonic" is added to the current approximation, a new harmonic is presented here replacing the previous one, the approximation signal is re-plotted, the new errors are computed, and the number of terms used in the current approximation is updated in the text message next to the main graph.

Figure 3 shows an example of an approximation. In this case, the original signal is a square-like wave, plotted in white, and the result of the approximation, after summing the DC component plus six harmonics/terms of the Fourier series expansion, is plotted in red, over the same graph. On the graph below, it is presented the plot of the next harmonic/term to be added to the result of the approximation plotted in red, if the "Add" button is pressed. The current error of the approximation over a period is also shown ($L_2 = 132.3553$ and $L_\infty = 52.5$), and it will decrease if more harmonics/terms are added to the approximation.

Note that the scales (and axes) used for the signals and harmonic plots are different, and automatically adapt from expansion to expansion. However, these scales remain constant during a particular expansion, so the student can realize the different weights that successive harmonics will have in the approximation. For example, figure 4 shows the result of the Fourier series approximation to a square-like wave, after using the DC term plus 18 harmonics. When compared to figure 3 we may note the big difference in the weights of harmonic number 7 and harmonic number 19 (obviously, the same applies to the error



Error
L_2 = 76,4923
L_∞ = 52,5001

Figure 4: Fourier series expansion of a square-like wave: DC term plus 18 harmonics.

$L_2 = 76.4923$ and $L_\infty = 52.5001$). Note that, in this case, L_∞ error remains constant (52.5); this is due to the Gibbs phenomenon (see, for example, (Jerri, 2011) for details).

Figures 5 and 6 show the Fourier series expansion approximation to a sawtooth-like wave. In figure 5 it is used the DC term only to the approximation (all the approximations start with the DC term only). It is well visible that, in this case, DC $= 0$ and so it overlaps the t (time) axis in the plot. Also note the first harmonic term was scaled to completely fill the plotting area reserved to the plot of the harmonics. Now, from figure 6 we can see that the fifth harmonic term will have a much lower weight in the series final result. Note also that the time axis is now well visible in the approximation plot; as stated above, when the approximation started the null DC term overlapped the time axis.

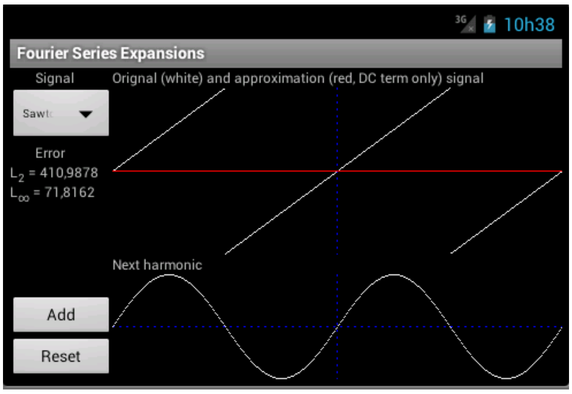
A help menu is also available, by pressing the “menu” button of the smartphone/tablet.

4 SOME RESULTS

We have distributed a copy of the application directly to our students, i.e., the students installed the application directly on their devices without the need of downloading it from “Google Play”, after the subject was taught in class.

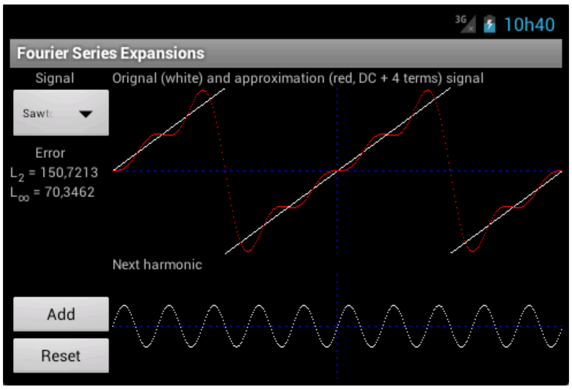
We have anonymously surveyed our students with the following questions:

1. Gender.
2. Do you consider that the application has an ease to use interface?
3. Have you ever used or needed to use the help menu?



Error
L_2 = 410,9878
L_∞ = 71,8162

Figure 5: Fourier series expansion of a sawtooth-like wave: DC term only.



Error
L_2 = 150,7213
L_∞ = 70,3462

Figure 6: Fourier series expansion of a sawtooth-like wave: DC term plus four harmonics.

4. Do you prefer a web-based tool (applet) or this (android) version? Please tell us why.
5. Do you think that the application matches/covers the contents taught related to the Fourier series?
6. Do you think this application helped you in understanding the Fourier series (basics, how it works and its applicability)?
7. Do you think this application helped you in understanding other topics/subjects in this or other courses?
8. Do you think it would be beneficial to have similar tools in other subjects & courses?

In a total of 85 enrolled students, 55 completed the survey, from which 50 (91%) were males and 5 (9%) females. 51 (93%) of the surveyed students consider that the application has an ease to use interface, and only 4 (7%) found it somehow difficult or hard to use. However, only 2 (4%) of the total responding students have tried the help menu; curiously, these students are two of the four considering the application hard or difficult to use.

From the responding students, 47 (85%) prefer this android version, when compared to other web-based applications (applet like) available on the Internet. When asked why, they answered that this application "is really portable (in the sense that we don't need to be always connected; we can do simulations even if we do not have Internet access)" and "it seems that the interface was designed and developed to extract the maximum from my android device, in contrast to a web-based applet were we constantly need to adjust the screen size, resolution, among other". The other 8 (15%) students consider the web-based (applet) version more suited to their needs: "don't like to install apps" and "web-based applications are really platform independent" were the two main reasons presented for that. In this group we also counted the iOS (iPhone/iPad) users, who revealed that they are willing for an iOS version of the tool.

A total of 53 (96%) of the responding students consider that the tool matches/covers the subjects studied within the Fourier series topics, and 54 (98%) believe that it helped them in understanding the basics of the Fourier series, how it works and its applicability. In addition, 50 (91%) students consider that this tool helped them to understand other topics under this course and even in other courses. The referred topics include: some signals' properties (like symmetry, frequency, etc.); Fourier transform; math series construction; and programming (the code of the application was made available to our students).

When asked if other courses/topics/subjects should benefit from similar tools/applications the answer was the answer was unanimous (100% (55) of the responding students said yes).

5 CONCLUSIONS

Fourier series expansions are among the problems that an electrical engineer most often faces. An undergraduate course in the subject not only provides the student with relevant know-how concerning the problems, but may also be of considerable value in understanding how a background in Fourier and numerical analysis can be applied in the field, to concrete engineering problems.

In this context, we felt a need for tools that could be easily used inside or outside the classroom, in formal and informal contexts, and at the same time were easy to update and maintain. The application that we have described allows the student to try several Fourier series expansions on a set of typical signals, and then compare the results in an easy-to-use environment, and using their own Android powered devices.

The application, named "FouSE—Fourier Series Expansions", is freely available for download from "Google Play" (www.google.com), and can be used by the students in their daily work, inside or outside the classroom, and have proved to be a valuable tool for teaching and understanding Fourier series expansions.

ACKNOWLEDGEMENTS

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Progressive Semiotic Enrichment
Designing Learning Content Metadata for Web 3.0

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Keywords: Metadata, Content Development, Web 3.0, Semiotics, Semantics, Design, Progressive Enhancement.

Abstract: Web 3.0 allows learning content to be semantically annotated thus facilitating improved information retrieval, reuse and integration. This short paper presents a design pattern for progressively describing and annotating learning content components in Web 3.0 based on key concepts adopted from social semiotics. Furthermore, the paper exemplifies how this design pattern may be encoded using a structured data format such as RDFa Lite and a general-purpose vocabulary like schema.org. Finally, some potential benefits of this approach are briefly touched upon.

1 INTRODUCTION

As structured data formats such as Microdata and RDFa (Lite) and vocabularies like schema.org, ALOCOM, LRMI and SKOS are maturing and becoming widely available, learning content on the Web can now be described and annotated in greater detail thus facilitating increasingly sophisticated automatic information processing (retrieval, rendering, reuse and integration). In theory, embedded learning content objects like images, diagrams and videos can be unbundled and reused across disparate materials and contexts; content can be shown in different modes and forms and data sets about a specific concept, topic or event can be aggregated from different sources.

This potential is closely related to the introduction and application of HTML5, the latest version of the popular format, or markup language to be more precise, used in most existing web pages, including web-based learning materials. Besides enhanced functionality for handling multimedia, interactivity and content organization, HTML5 affords a set of mechanisms for embedding structured data to describe the semantic contents of web documents: what they are about, what their communicative purpose is, etc.

Mature and easy-to-use standards and technologies, of course, are not enough. To create reusable learning content and to build working e-learning solutions in Web 3.0, sound and viable design approaches need to be devised, implemented and tested. For instance, content developers need design patterns for structuring and semantically annotating content in ways that are meaningful, transparent, consistent and scalable.

In this short paper, a design pattern for describing and annotating embedded learning content components in Web 3.0 is proposed. A design pattern may be defined as a general solution to a recurring design problem.

The design pattern presented here may be said to be theory-driven in the sense that it draws on key concepts adopted from social semiotics, a theoretical framework for analyzing meaning and meaning making in multimodal materials. But it is also practice-oriented insofar as it may be applied as an integral part of a concrete web design and development methodology such as progressive enhancement (see below). The design pattern itself allows content developers to enrich learning objects with inline metadata detailing their semiotic characteristics, notably their medium, representation, genre and metafunctions. By employing such a design pattern, content developers may explicitly, and in a standardized manner, link documents to domains, or more abstractly, resources to reality.

In addition, the paper exemplifies how this design pattern may be encoded using a structured data format such as RDFa Lite and a general-purpose vocabulary like schema.org. Finally, some potential benefits of this approach are briefly hinted at.

2 PROGRESSIVE ENHANCEMENT

These days, much web design and development (for learning) is based on the notion of progressive enhancement. The idea is that basic content and functionality should be available to all users irrespective of which browser (version) they are using, what hardware platform they employ or what assistive technology they may need (e.g. screen readers). In a word, basic content and functionality should be *accessible*. Content and functionality can then be progressively enhanced through presentation (typography and layout) or interactivity so that those having the newest browser (version) get a richer or an aesthetically more pleasing web experience (see for instance Allsopp, 2009 and Gustafson, 2011).

The ideal of progressive enhancement can be built directly into a HTML5 web document as shown in figure 1.

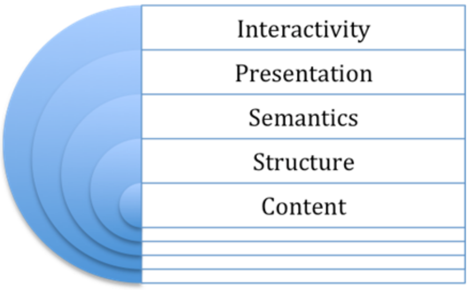

Figure 1: Progressive enhancement.

The core of the document is the *content*: text, images and multimedia objects. This content is organized into a transparent formal *structure* typically consisting of sections, subsections, headings, paragraphs and so on. These elements may then be encoded to signal their *semantics*. Further information can be added to specify what the *presentation* of the document parts is going to look like, while *interaction* elements finally provide a way for users to control and navigate the document. What is important here is the layered nature of the model: outer layers have inner layers within their scope. Interaction can be applied to presentation (e.g. a button for changing color or font-size), and semantics to structure (e.g. markup to signal that a certain paragraph is a procedure or a summary).

The construction of structure, semantics, presentation and interaction is normally done using technologies like HTML tags (structure), structured data formats like Microformats, Microdata or RDFa (semantics), CSS (presentation) and JavaScript (interaction) as shown in figure 2.

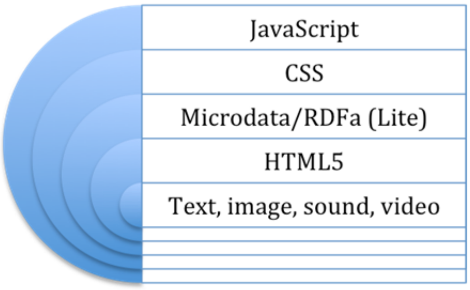

Figure 2: Technologies for progressive enhancement.

2.1 Semantic Enrichment

As for the semantic, or descriptive, layer, the key question is not only what semantic characteristics to capture and annotate, and at what level of detail, but also what model to adopt.

We propose a content metadata design pattern, which is loosely grounded in semiotic theory, more specifically social semiotics (see for instance Kress and Van Leeuwen, 2001; Van Leeuwen, 2005 and Bezemer and Kress, 2008). In social semiotics, the focus is on meaning and meaning making in multimodal contexts. From a social semiotic perspective, meaning is constructed through semiotic resources, interacting complexes of signs, in a variety of modes (writing, images, layout, gesture, etc.) and distributed through different media both electronic and physical. Signs are shaped through genres and can perform different communicative functions: they can construe reality (ideational meaning), create communicative coherence (textual meaning) or relate speakers/writers to addressees (interpersonal meaning).

The model proposed here presents a web-based learning object as a semiotic resource having (at least) four central facets: medium, representation, genre and metafunctions. The model is depicted in figure 3:

Medium may be perceived as the channel, or frame, through which the content is communicated or distributed. So, a medium may be a blog posting, a wiki page or a social medium like FaceBook.

Representation refers to an object's multimodal representation. Is it a written text, an image, a video object or a combination or modes?

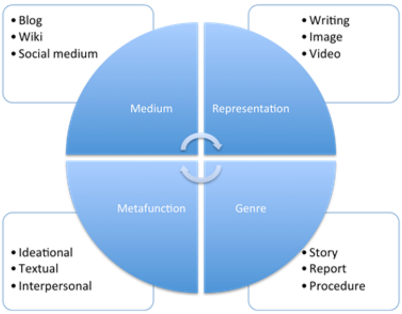

Figure 3: Learning objects as semiotic resources.

A *genre* is a goal-oriented semantic configuration or template "for getting things done" communicatively in a certain culture (see Martin and Rose, 2008 and Vorvilas et al., 2011). Examples of genres are stories, procedures and reports (broadly descriptions of entities). Such genres may combine to form macrogenres, typical of larger units of educational material (e.g. textbooks).

Metafunctions are the semantic elements that can be identified in an object. *Ideational meaning* is what the object is about (persons, places, events and concepts), *textual meaning* is what makes the object (more or less) cohesive and coherent, internally and externally, and *interpersonal meaning* is meaning associated with the relationship between the creator or designer of the object and his or her audience.

The upper part of the learning object model in figure 3 has mainly to do with the form of the resource (signifier) while the lower part relates to its content or meaning (signified). The arrows indicate the "natural progression" in analysis from a concrete communication channel to more or less elusive meanings.

The four semiotic categories may themselves be progressively refined. For instance, a learning content component might not only be categorized as an image but also as a diagram or even a concept map. And a specific instance of a genre like procedure could be subtyped as a food recipe or an installation guide.

So, a learning content object might be described along the following lines:

- Medium: Blog posting > tweet
- Representation: Image > diagram > concept map
- Genre: Report > classifying report
- Metafunction: Ideational meaning > concepts (birds > birds of prey > eagles, hawks, vultures)

That is to say, this bundle of metadata designates a concept map published in a tweet on Twitter and giving a classificational description of a set of concepts, namely birds of prey.

Another object might have these characteristics:

- Medium: Wiki page
- Representation: Writing
- Genre: History > historical recount
- Metafunction: Ideational meaning > events (Battle of the Little Bighorn), persons (Custer, Crazy Horse), places (Little Bighorn River); textual meaning > external link > elaboration

Here a piece of writing in a wiki page gives a historical recount of the Battle of the Little Bighorn involving certain persons and places and containing a link to an external resource providing additional information on the event.

In other words, this semiotic descriptive model may be conceived of as a kind of extensible facetted classification in which any learning component may belong to several types and subtypes or be viewed from several perspectives.

Now, further information may be attached to these four main facets. For instance, didactical metadata may be added to the learning object as a representation to indicate degree of interactivity, learning style, etc. Ideational meanings may be expanded: events may be located in place and time, persons may be described or depicted and places may be encoded with geospatial coordinates.

Also, the metadata may describe nested structures, as it were. For instance, in a concept map classifying birds of prey, there might be images attached to the various types of bird. These images may themselves be subjected to semantic description and annotation.

Semiotic metadata should not be seen as an alternative to more traditional metadata schemes such as Dublin Core, LOM or SCORM (e.g. Robertson, 2011) but rather as an extension. They make it possible, it is believed, to tie a learning resource more closely to its domain and to specify in greater detail what communicative intentions it seeks to realize. Moreover, as argued below, they may also have a role to play as part of the actual learning design of the resource in which they are embedded.

2.2 Encoding

It is beyond the scope of this short paper to discuss the many possibilities of representing semiotic metadata as embedded semantic markup in HTML5 documents using structured data formats such as Microdata and RDFa (Lite). The following example, however, suggests one simple approach. It makes use of RDFa Lite syntax and the schema.org vocabulary:

```
<!DOCTYPE HTML>
<html>
<body vocab="http://schema.org">
<article typeof="Article
CreativeWork/Medium/Wikipage
CreativeWork/Representation/Writing
CreativeWork/Genre/Report/DescriptiveRe
port">
<div
property="about/metafunction/ideational
Meaning" typeof="Person/General">
<h1 property="name">General Custer</h1>
<p>George Armstrong Custer(December 5,
1839 – June 25, 1876) was a United
States Army officer and cavalry
commander in the <span
property="performerIn"
typeof="Event"><span
property="name">American Civil
War</span></span> and the Indian Wars.
Raised in Michigan and Ohio, Custer was
admitted to West Point in 1858, where
he graduated last in his class.
However, with the outbreak of the Civil
War, all potential officers were
needed, and Custer was called to serve
with the Union Army.</p>
<img property="image"
src="http://upload.wikimedia.org/wikipe
dia/commons/thumb/8/83/Custer_Portrait_
Restored.jpg/250px-
Custer_Portrait_Restored.jpg" />
</div>
</article>
</body>
</html>
```

This snippet of text copied from Wikipedia is marked up with common HTML5 elements such as <body>, <article>, <p>, <h1> and <img> to indicate structural components like paragraph, heading and image. These elements contain semantic markup based on schema.org classes and properties. They formally state that this is an *article* about a *person* whose *name* is Custer who was a *performer in* an *event* whose *name* was the American civil war and that it is indeed his image that is included in the text.

The schema.org vocabulary allows content developers to extend and customize its categories and properties. For instance, in the representation above it is specified that Custer was not only a person but in fact also a general (`typeof="Person/General")`.

And it is this extension mechanism we have employed to include semiotic metadata. To indicate the medium, representation and genre of the resource we have extended, or specialized, the schema.org category of *Creative Work* and to signal ideational meanings in this text, we have extended the *about* property. (Search engines like Google's do not know about these extended notions of *general*, *medium* and *ideational meaning* and so on, of course, but they will still be able to act on the core categories and properties like *person* and *about*).

In figure 4 a semantic/semiotic representation of the resource is shown when fed to an RDFa processor (http://rdfa.info/play).

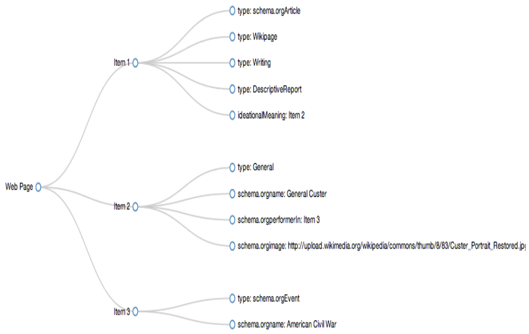

Figure 4: Semiotic representation of sample text.

For the sake of simplicity, only one vocabulary is instantiated in the Custer example. But structured data formats like Microdata and RDFa (Lite) actually allow several schemas to be mixed in an HTML5 document. For instance, in a longer document we might have included categories and properties from the FOAF vocabulary ("Friend of a friend") to specify General Custer's relations to other historical persons or referred to the Dublin Core vocabulary to add details about the document as a digital resource. And if the text had contained any hypertext links, we might have pointed to classes in the Salt Rhetorical Ontology to specify their communicative function.

3 BENEFITS AND WIDER PERSPECTIVES

What, then, are the benefits of marking up semiotic resources, complexes of meaningful signs, in learning materials? It may be argued that gains may be achieved in the following areas:

Firstly, the quality of information retrieval will no doubt be enhanced. It will eventually be possible to formulate more precise queries in search engines. Queries like "Find a concept map in English classifiying birds of prey and containing pictures of them" are no longer but a futuristic dream. (Google's Knowledge Graph is evidence of this trend).

Secondly, linking content components across web sites may be done in more explicit and principled ways. A hyperlink may denote an ideational relation between two domain entities (person A *is the brother of* person B) or a textual, or communicative, relationship (paragraph A *is a summary* of section B). And if global identiers are used, this is effectively tantamount to exposing, or attaching, learning objects to the Web of Data using linked data (see Heath and Bizer, 2011).

Thirdly, the reuse of embedded content components is also likely to become easier as these will be "unbundled" to a greater extent.

Fourthly, embedded semiotic annotation may provide an additional affordance, which has to do with the *learning potential* of learning objects, rather than just their retrieval, linking or reuse. The reason is that such metadata may be construed, and utilized, as what we may call *semiotic enzymes,* hidden elements enabling learning designs to be (dynamically) altered in various ways to cater for different user preferences, learning styles, rendering devices, etc. (see Johnsen, 2012). As an example, inline semiotic markup may be used to actively support one or more of Mayer's principles of multimedia learning (Mayer, 2009), in particular his "principle of signalling", i.e. the guideline advocating the use of conceptual structure markers in learning materials. Embedded semiotic tags could be used, say, as source data for dynamically creating graphic organizers, spatial arrangements intended to visually map the conceptual or narrative structure of a piece of text and hence facilitate its comprehension (see Stull and Mayer, 2007).

And since semiotic encoding can be done using standards like Microdata and RDFa (Lite), reusable style sheets, templates or widgets processing these semiotic metadata can be developed and shared on a global scale, especially for widely used categories like events, persons and places. For example, a college professor publishing a history textbook on the web might link the document to an external widget creating a visual timeline based on the events mentioned in the text. Or a learner might download a browser plug-in to flag all occurrences of concepts of interest when surfing the web.

This affordance opens a whole set of opportunities that could, for lack of a better term, be called "Learning Content Design as a Service" (LCDaaS). The idea itself is simple: content providers like professors and teachers will only have to concentrate on constructing structured materials ("basic content") but will be able to link these materials to (dynamic) designs and in this way create richer and more engaging learning resources. And users will have a greater say in deciding what design options they want for the materials they study (visual support, interactivity, etc.).

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One-on-One Approach for Open Online Courses

Focusing on Large-Scale Online Courses

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Keywords: Open Education, Large-Scale Online Course, e-Books, e-Learning, GakuNin.

Abstract: Large-Scale Online Course (LSOC) requires stable and low-cost services and special learning and teaching methods because numerous learners are generally studying on a course for free. This paper proposes Learning Support System (LSS) using e-book with an access management federation designed for LSOC. The proposed LSS reaches the solution to a flipped teaching and one-on-one approach of the massive learner using e-book, which is a new e-portal alternative to a web.

1 INTRODUCTION

Recently, the utilization of Massive Open Online Courses (MOOCs) are increasingly attracting attention. MOOCs are an emerging tool of open education that allows anyone who wants to participate to freely study on the Internet. It is estimated that hundreds of thousands of students enroll in MOOCs (Lewin, 2012). Ivan Illich predicted in “Deschooling Society” that the Information Computer Technology would provide an equal opportunity of open education (Illich 1971). The activity of MOOCs was initially influenced by his philosophy.

Large Scale Online Course (LSOC) like MOOCs have the potential to bring revolutionary change to education, especially higher education because of this equal opportunity.

However, LSOC including MOOCs face challenges in motivating learners and managing system operation because the existing Learning Support System (LSS) are limited by conventional technology and methods. Therefore traditional LSS do not meet the evolving specifications of LSOC.

This paper discusses a new LSS that combines the benefits of e-books with an Access Management Federation (AMF). This LSS will facilitate one-to-one learning on LSOC even when there are hundreds of thousands of learners.

2 LSS FOCUSING ON LSOC

The differences between LSOC and traditional courses that utilize e-learning systems include scale (number of learners) and cost (fees). It is estimated that hundreds of thousands of students initially take a MOOC at no cost (Carr, 2012). LSOC should meet the following requirements.

- Provide a stable operation for online courses for numerous learners
- Secure sustainable revenue for free open online courses
- Provide efficient methods to motivate learners for self-study.

As Hill points out (Figure 1), MOOCs have barely addressed significant educational problems relating to revenue models, credentialing, accreditation, course completion rate, and learner authentication (Hill, 2012).

Therefore, LSS designed for LSOCs require the following.

A) Stable and Low-Cost Service：
Stability and afforadable services are essential for a course having large numbers of learners. Therefore it is imperative that the LSS should be able to integrate with different media platforms.

B) Learning Methods Selected by Learners' Intentions:
The LSS should provide diverse learning

methods chosen on the basis of the individual learner's intentions, such as receiving their evaluation of learning outcomes and accreditation or credit.

C) One-to-One Approach:
The LSS should provide one-to-one relationship that is unrealizable in traditional classroom between a teacher and a large number of learners.

3 LSS ON MOOCs

Existing LSOCs like MOOCs are insufficient for the three above mentioned reasons. Here are several significant examples of LSOC. The activities of MOOCs include two distinctive learning models of cMOOCs and xMOOCs (Siemens, 2012). cMOOCs are based on the idea of Web2.0 with interactive learning between educators and learners on the internet. cMOOCs provide the learning environment of the social network between educators and learners by utilizing existing internet resources such as wiki, blogs, and social networking sites like Twitter and Facebook.

xMOOCs follows the method of conventional e-learning and provides online courses with its original learning support system.

Both LSSs have their distinctive challenges.

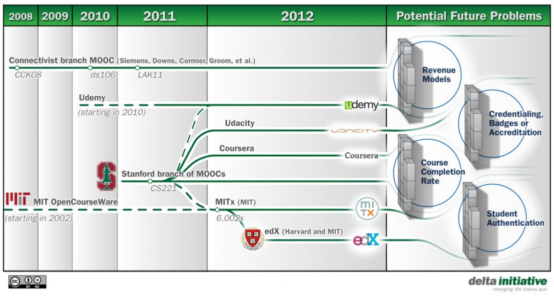


Figure 1: The Two Branches of MOOCs. (HILL, 2012).

3.1 For Stable and Low-cost Service

As explained above, a cMOOC creates LSS in combination with the existing available service on the Internet such as social network service and provides its online courses without own LSS for 1.5 million learners (Carr, 2012).

In principle, the idea of cMOOC is effective for providing a stable and affordable LSOC because it is not dependent upon a particular network infrastructure.

xMOOCs which have their own LSS, provide courses through their own original service. As such, xMOOCs require substantial investment and face difficulties in providing stable operations. Actually, Coursera experienced a partial outage caused by its AWS's system failure in October 2012 (examiner.com, 2012). The accident impacted close to million users and clearly presented a significant challenge.

3.2 Learning Method Selected based on Learners

LSS's concepts of cMOOCs and xMOOCs are incompatible. Hence learners can select neither learning support systems nor learning methods, according to their learning purposes.

cMOOCs have an advantage in their stable and low-cost LSS. However, this LSS cannot be utilized to evaluate learning outcomes. cMOOCs are indifferent to learning assessment, accreditation, and credit, even though they are interested in dissemination of learning.

In contrast, xMOOCs can be utilized to evaluate a student's learning outcomes and grant credit. They follow the method of conventional e-learning and provide online courses with its original LSS. In this regard, Siemens, as one of the early developers of cMOOCs, criticizes xMOOCs as merely traditional learning using lecture videos and quizzes.

LSS designed for LSOC should be capable of dealing with any kind of LSOC even if LSOC has different methods of implementation.

3.3 One-on-One Teaching

Many LSOCs such as cMOOCs and xMOOCs have functions making it possible to create a one-on-one relationship between the educator and the learner on chat, live video, and SNS.

One-on-one approach is an essential function of the LSS and should be carefully examined. The existing LSOC that both an educator and teaching assistants teach numerous learners is not truly one-on-one teaching. One-on-one teaching should be that one educator teaches one learner.

4 DEVELOPING THE LSS USING E-BOOK

The LSS designed for LSOC requires the functions that allow for a stable and low-cost operation; learning methods based on learners; and a one-on-one approach between an educator and a learner.

The authors developed the new LSS using e-book that is a substitute for web interface.

4.1 LSS using e-Book

LSS using e-book has the following characteristics:

- The inherent functions of e-books allow various formats such as html, video as well as contents or learning topics on online courses to be packed into one book.
- e-Books can provide online course content through different media including web, mail, portable electric devices and e-book store.
- e-Books have high discoverability on the Internet, including assigned Digital Object Identifier (DOI).

Our newly developed LSS based on e-book have the following advantages.

1) Standardization:
   e-book structure inherited from traditional books has an established standard. In addition, e-book format has an established standard like epub format.
2) Portability:
   e-Book is readily portable.
3) Using varied the Internet resources:
   e-Book can provide diverse learning environment tailored for each learner combining use of learning contents and Internet resources such as SNS.
4) Content distribution:
   e-Book provides online courses through a variety of ways such as e-library, e-book store, websites, and e-mail.
5) Flipped Teaching:
   Learners freely can edit distributed contents of e-Book created by an educator. And this e-book will be prevalent in the LSOC community worldwide (Figure 2).

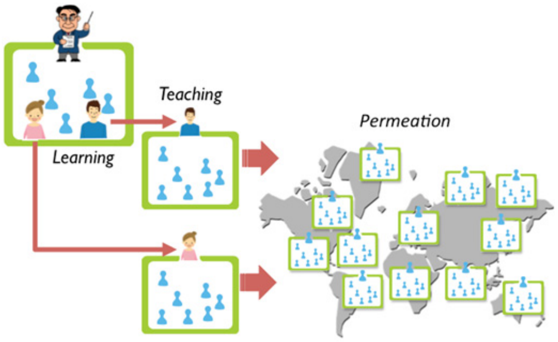


Figure 2: Flipped teaching.

6) Diversity of access methods:
   Learners study online courses by various access methods regardless if there is the Internet access or not.
7) One-on-One approach:
   The environment for conducting one-on-one approach is easily implemented by simply adding the application.

The authors designed LSS based on e-book by utilizing the formerly mentioned advantages (Hori 2101). Figure 3 below shows the concept of LSS.

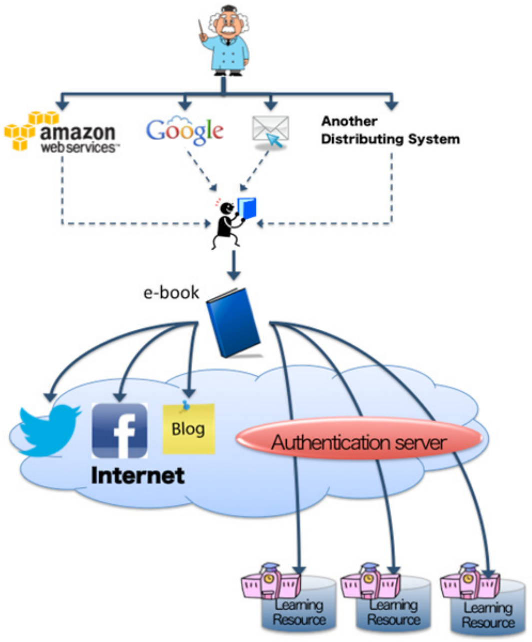


Figure 3: An Online Course Portal by e-book.

4.2 Three Essential Components for the LSS

LSS based on e-book consists of three essential components.

1) Discoverability:
   DOI, an element of metadata of network information resources, which overcomes URL's limitations like temporariness, attempts to identify digital media on various levels such as paragraphs, sentences, and figures. The assignment of a DOI makes it possible to identify learning resources of online courses.
2) Flipped Teaching:
   DOI name prefix can be assigned to each "flipped teaching" community within a LSOC. Each community can assign DOI numbers to their e-books. Herewith, discoverability and traceability are expected in these e-books thus guaranteeing product quality.

3) Learners Authentication:
As previously mentioned, e-book with academic AMF realizes low-cost and high reliability user authentication.

4.3 Access to Academic AMF

The specification of student's learning resource is necessary for the evaluation of student's learning outcomes. In this case, student authentication is required. For example, the proctors on Coursera monitor learners via a mix of webcams and `keyboard dynamics' for strict authentication (chronicle.com, 2013). However, the authors will develop a low-cost system with the Access Management Federation (AMF) to evaluate learning outcomes.

The authors adopt a common authentication platform that the National Institute of Informatics (NII) promotes the Academic AMF in Japan (GakuNin) (Yamaji et al., 2010).

The Academic AMF in Japan consists of both users (universities) and producers (publishers) of academic e-resources. By mutually implementing rules and policies stipulated by the Federation, organizations can easily access each other.

A user's authenticated account of each authorized participant in GakuNin is issued after verifying its identity, which is guaranteed by the participants, including higher education institutes.

4.4 Creating Microlecture Contents

The authors have introduced a one-minute lecture video (microlecture) as the method to motivate learners (Figure 4).

TIESは「連携・共有・公開」を目的として、1998年に高等教育機関とその教職員による小さなコミュニティとしてその活動を開始しました。

我々は、このコミュニティに対し、教育ポータルとしてeラーニングシステムを提供し、この教育ポータルを中心として、大学講義の公開により、閉鎖的な大学教育の改革を推進してきました。

今回、TIESではこの教育ポータルのあり方を根本から見直し、eラーニングシステムをオープンソースとして公開するとともに、電子書籍を中心とした全く新しい発想での大学講義の公開を推進することとしました。

これは、今までの、Webを中心としたICT教育やeラーニングとは違い、大学教員の「知識」を電子書籍というパッケージにまとめ、電子書籍をポータルとして教育を提供するという、全く新しい発想に基づいた教育ポータルです。

本書では、その意義と効果について紹介します。

Figure 4: Example for microlecture.

Microlectures are brief lecture videos focused on key concepts and are widely utilized by Khan Academy and TED-Ed. EDUCAUSE cites microlectures as a new educational approach (EDUCAUSE, 2012).

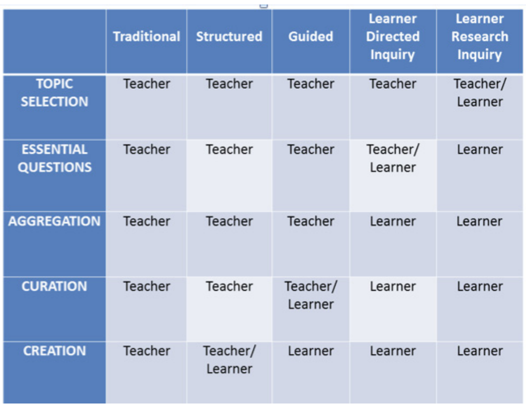
Microlectures allow learners to be free of time constraints, increase completion rates, and generate a sense among learners that they are receiving a face-to-face lecture via mobile.

4.5 Flipped Teaching on e-Book

Table 1 by Gende shows roles of both teachers and learners in the process of creating a textbook based on e-book (Gende, 2012). For example, in the learner-centric approach, learners are involved in making the textbook in Research and the Inquiry; while teachers are also involved in Topic Selection and Essential Questions. The same process happens when creating e-books. Thus, learners can add and revise in e-book provided by an educator in the process of the Inquiry or the Research.

The learner may become the teacher and create a new learner's community and redistribute the e-book to other learners who belong to the community. The learner has developed a deep understanding of educational contents thus contributed to the enhancement of the educational quality.

Table 1: Teacher and Learner Roles (Gende, 2012).



	Traditional	Structured	Guided	Learner Directed Inquiry	Learner Research Inquiry
TOPIC SELECTION	Teacher	Teacher	Teacher	Teacher	Teacher/ Learner
ESSENTIAL QUESTIONS	Teacher	Teacher	Teacher	Teacher/ Learner	Learner
AGGREGATION	Teacher	Teacher	Teacher	Learner	Learner
CURATION	Teacher	Teacher	Teacher/ Learner	Learner	Learner
CREATION	Teacher	Teacher/ Learner	Learner	Learner	Learner

4.6 One-on-One Approach based on e-Book

One educator has to handle diverse requests and intentions of numerous learners to create a one-on-one approach on LSOC. It is so challenging that many LSOCs depend on various means such as SNS and teaching assistants. In contrast, LSS based on e-book with AMF and DOI should make flipped teaching possible which can then enhance the quality of education. This LSS will lead to cooperation and collaboration between educators and learners on the Internet. A number of small communities based on one-on-one relationships can be formed.

5 THE CHiLO PROJECT

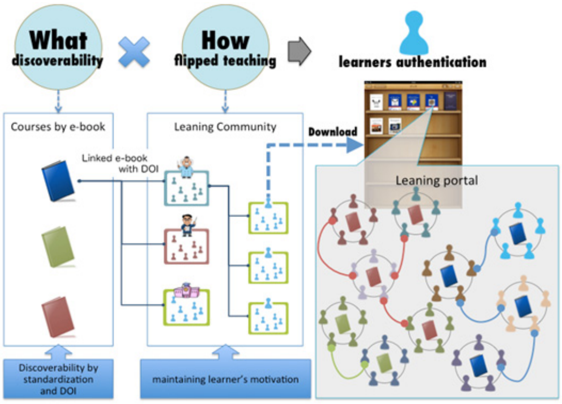


Figure 5: The CHiLO e-book distribution.

A Creative Higher Education on the Learning Open Course (CHiLO) is a new project for Open Online Course in Japan. Within this project, the authors of this paper aim developing new LSS based on e-book, which is called a CHiLO Book. In this LSS, e-book will consist of microlectures (Figure 4) and will provide authentication services endorsed by the GakuNin (Yamaji, 2010). Additionally, this e-book will be granted DOI to ensure discoverability and traceability. Finally, the CHiLO Book will contain varied Internet resources to replace website (Hori 2012).

These elements will realize flipped teaching, which may facilitate the creation of several small communities of learners in the LSOC (Figure 2). As a result, these the goal of one-on-one teaching will be achieved (Figure 5).

The CHiLO Book, which is distributed in these small communities, will continue to develop the educator-to-learner or learner-to-learner link and further promote mutual understanding of educational contents.

6 CONCLUSIONS

LSOCs hold the potential of resolving the challenge attaining educational equality and changing traditional pedagogy.

The authors propose an LSS based on the e-book, which will maintain learners' motivation, evaluate their learning outcomes, and provide stable and low-cost access.

LSS facilitates a one-on-one approach, provides diverse learning methods and environments chosen based on an individual learner's intentions, and utilizes the flipped teaching to enhance educational quality. This method also ensures learner authentication by using academic access management federation. Such functionality meets all requirements of LSS designed for LSOC.

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A Personalised Approach in Informal and Inquiry-based Learning

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Keywords: Personalised Learning, Self-regulated Learning, Personal Learning Environment, Informal Learning, Inquiry-based Learning.

Abstract: Personalised learning has emerged as a novel approach to learning, putting learners in the spotlight and providing them with the tools for building their own learning environments according to their learning needs and aspirations. Personalised learning is closely connected to self-regulated learning, which enables learners to take complete control over their learning. This paper presents the strategies involved with the application of personalised learning in two different case studies. These case studies originate from two European research projects and concern informal and inquiry-based learning respectively.

1 INTRODUCTION

Personal Learning Environments (PLEs) are gradually gaining ground over traditional Learning Management Systems (LMS) by facilitating the lone or collaborative study of user-chosen blends of content and courses from heterogeneous sources, including Open Educational Resources (OER).

The implementation of PLEs for supporting different types of learners involves a number of challenges. This paper presents two distinct case studies where personalised learning has either been applied or is currently being applied. The first case study has to do with informal learning in the context of the European project ROLE. The second case study builds on the lessons learned from the first case study and is concerned with inquiry-based learning in the context of the new European project weSPOT.

The remainder of this paper is organised as follows: Section 2 describes the background and introduces the main concepts related to personalised and self-regulated learning. Section 3 presents the informal learning case study of the ROLE project and discusses the methodology adopted for personalised learning in this case. Section 4 introduces the inquiry-based learning case study of the weSPOT project and describes the strategy for deploying personalised learning in this context. Finally, the paper is concluded in section 5 and the next steps of this work are outlined.

2 BACKGROUND

The Learning Management System (LMS) has dominated Technology-Enhanced Learning (TEL) for several years. It has been widely used by academic institutions for delivering their distance learning programmes, as well as for supporting their students outside the classroom. The LMS has been a powerful tool in the hands of educators, enabling them to complement face-to-face teaching in the classroom with remote work by individual students, as well as groups of them. Popular examples of such systems used by the academic and the business world include Blackboard (www.blackboard.com), Moodle (http://moodle.org), and Sakai (http://sakaiproject.org) (Bri et al., 2009; Wainwright et al., 2007; Abel, 2006; Watson et al., 2007).

However, the advent of Web 2.0 has altered the landscape in TEL. Learners nowadays have access to a variety of learning tools and services on the web. These tools and services are usually provided by different vendors and in many cases are open and free. Repositories like Wikipedia (www.wikipedia.org), YouTube (www.youtube.com), SlideShare (www.slideshare.net) and iTunes U (www.apple.com/education/itunes-u) offer access to a wide range of learning materials for free. Augmenting and configuring the diverse and distributed Web 2.0 tools and services in order to address the needs and preferences of individual learners is a significant challenge for modern online learning environments.

As opposed to formal learning, which is mostly instructor-led, informal learning is driven by self-study and the initiative of individuals, as well as communities of learners with common goals. The transition from the traditional approach of LMS to Web 2.0-based learning solutions bears significant benefits for informal learners. It puts emphasis to their needs and preferences, providing them with a wider choice of learning resources to choose from. In addition, the success of initiatives such as the Khan Academy (www.khanacademy.org) has proven the importance of Web 2.0-enabled crowdsourcing in informal learning.

The Personal Learning Environment (PLE) is a facility for an individual to access, aggregate, manipulate and share digital artefacts of their ongoing learning experiences. The PLE follows a learner-centric approach, allowing the use of lightweight services and tools that belong to and are controlled by individual learners. Rather than integrating different services into a centralised system, the PLE provides learners with a variety of services and hands over control to them to select and use these services the way they deem fit (Chatti et al., 2007; Fiedler and Väljataga, 2010; Wilson, 2008).

The emergence of the PLE has greatly facilitated the use and sharing of open and reusable learning resources online. Learners can access, download, remix, and republish a wide variety of learning materials through open services provided on the cloud. Open Educational Resources (OER) can be described as “teaching, learning and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use or repurposing by others depending on which Creative Commons license is used” (Atkins et al., 2007).

Self-regulated learning (SRL) comprises an essential aspect of the PLE, as it enables learners to become “metacognitively, motivationally, and behaviourally active participants in their own learning process” (Zimmerman, 1989). Although the psycho-pedagogical theories around SRL predate very much the advent of the PLE, SRL is a core characteristic of the latter. SRL is enabled within the PLE through the assembly of independent resources in a way that fulfils a specific learning goal. By following this paradigm, the PLE allows learners to regulate their own learning, thus greatly enhancing their learning

3 AN INFORMAL LEARNING CASE STUDY

The European project ROLE (Responsive Open Learning Environments; www.role-project.eu) is aiming at empowering learners for lifelong and personalised learning within a responsive open learning environment. In order to study and evaluate the applications of PLEs in a variety of learning contexts, the ROLE project has setup a number of test-beds. The Open University (OU), UK comprises one of the ROLE test-beds, concerning the learners’ potential transition from formal to informal learning. This transition is being implemented within this test-bed as a transition from the traditional LMS towards the PLE paradigm (Mikroyannidis, 2011; Mikroyannidis and Connolly, 2012a; Mikroyannidis and Connolly, 2012b).

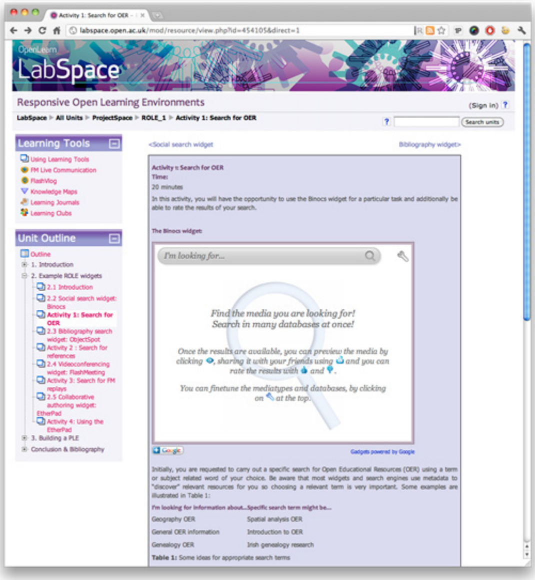
The test-bed in question is the OER repository OpenLearn offered by the OU. OpenLearn (http://openlearn.open.ac.uk) currently offers more than 6,000 hours of study materials in a variety of formats. These include materials repurposed as OER from original OU courses i.e. formal delivery as well as bespoke OER created by both OpenLearn academics and non-OU educators, i.e. enabling informal delivery.

OpenLearn users are primarily informal learners, who want to find and study OER either individually or in collaboration with others. These learners can be in formal education e.g. taking an accredited University course elsewhere and simply looking for additional materials to add value to their primary course or they maybe, what is often described as, “leisure” learners i.e. those who simply want to learn for themselves with no expectation of formal accreditation.

OpenLearn currently uses Moodle as a LMS platform. Therefore, in order to add value to those potential learning experiences, this test-bed has endeavoured to raise awareness of PLEs and SRL with the community of informal learners that are actively using OpenLearn for their learning. This has been done primarily through the production of bespoke OER as OpenLearn courses that raise awareness about ROLE and its approach in personalised and self-regulated learning (see http://tinyurl.com/role-course and http://tinyurl.com/role-srl-course for more details). Figure 1 shows a sample learning activity from these courses. The learning activity in question introduces learners to the use of a widget for finding learning resources.

This transition attempts to transform and improve the OpenLearn user's experience by enabling individuals to build and personalise their learning environment, thus gaining more control over their learning process through the use and manipulation of OER study materials. The aforementioned bespoke OER that have been developed by the ROLE project also provide guidance on how someone can use a PLE in order to better organise their learning and improve their SRL skills.

In addition, the adoption of certain ROLE widgets inside study units of the OpenLearn platform is offering further value to informal learners by supporting a stronger framework to foster learning communities. This presents an opportunity to individual informal learners to be part of a shared learning experience instead of a lone study.



Activity 1: Search for OER

Time:

20 minutes

In this activity, you will have the opportunity to use the Binocs widget for a particular task and additionally be able to rate the results of your search.

The Binocs widget:

Find the media you are looking for!
Search in many databases at once!

Once the results are available, you can preview the media by clicking 👁, sharing it with your friends using ⇪ and you can rate the results with 👍 and 👎.

You can finetune the mediatypes and databases, by clicking on 🔧 at the top.

Initially, you are requested to carry out a specific search for Open Educational Resources (OER) using a term or subject related word of your choice. Be aware that most widgets and search engines use metadata to "discover" relevant resources for you so choosing a relevant term is very important. Some examples are illustrated in Table 1:

I'm looking for information about...	Specific search term might be...
Geography OER	Spatial analysis OER
General OER information	Introduction to OER
Genealogy OER	Irish genealogy research

Table 1: Some ideas for appropriate search terms

Figure 1: A learning activity featuring a ROLE widget inside an OpenLearn course.

4 AN INQUIRY-BASED LEARNING CASE STUDY

weSPOT (Working Environment with Social, Personal and Open Technologies for Inquiry Based Learning; http://wespot-project.eu) is a new European project, aiming at propagating scientific inquiry as the approach for science learning and teaching in combination with today's curricula and teaching practices. weSPOT aspires to lower the threshold for linking everyday life with science teaching in schools by technology. weSPOT supports the meaningful contextualization of scientific concepts by relating them to personal curiosity, experiences and reasoning.

weSPOT addresses several challenges in the area of science learning and technology support for building personal conceptual knowledge. The project focuses on inquiry-based learning with a theoretically sound and technology supported personal inquiry approach. In inquiry based-learning, learners take the role of an explorer and scientist and are motivated by their personal curiosity, guided by self-reflection, and develop knowledge personal and collaborative sense-making and reasoning.

As we have learned from the ROLE project, what is often missing from the PLE, is not the abundance of tools and services, but the means for binding them together in a meaningful way. weSPOT will address this issue by providing ways for the integration of data originating from different inquiry tools and services. Most importantly though, weSPOT will enable the cognitive integration of inquiry tools by connecting them with the students' profiles, as well as their social and curricular context. Individual and collaborative student actions taking place within different inquiry tools will update the learning history and learning goals of the student, thus providing them with a cohesive environment for monitoring and self-regulating their learning process and progress.

The Web 2.0 paradigm offers new opportunities for social learning by facilitating interactions with other learners and building a sense of connection that can foster trust and affirmation (Weller, 2009). Social learning, according to Hagel, et al. (Hagel et al., 2010), is dictated by recent shifts in education, which have altered the ways we catalyze learning and innovation. Key ingredients in this evolving landscape are the quality of interpersonal relationships, discourse, personal motivation, as well as tacit over explicit knowledge. Social media offer a variety of collaborative resources and facilities, which can complement and enrich the individual's personal learning space, as shown in Figure 2.

weSPOT will provide students with the ability to build their own inquiry-based learning environment, enriched with social and collaborative features. This will allow them to filter inquiry resources and tools according to their own needs and preferences. Students will be able to self-regulate their inquiry-based learning process by planning, organising and executing it in collaboration with their peers. Students will also be able interact with their peers in order to reflect on their inquiry process, receive and provide feedback, mentor each other, thus forming meaningful social connections that will help and motivate them in their learning. From a learner's perspective, this approach will offer them access to personalized bundles of inquiry resources augmented with social media, which they will be able to manage and control from within their personal learning space.

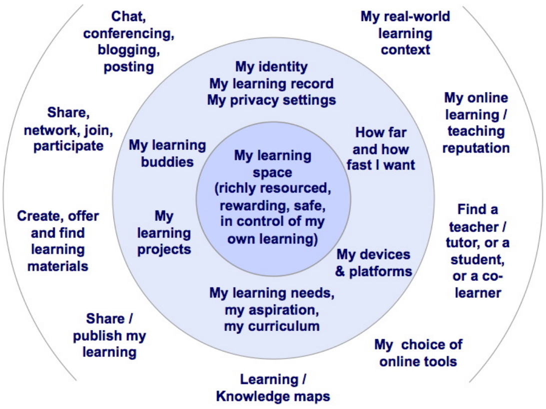


Figure 2: Personal learning space, resources, and social interactions (Shum and Ferguson, 2010).

5 CONCLUSIONS

Personalised and self-regulated learning is offering new capabilities to learners, by allowing them to build and use learning environments that meet their particular learning needs, thus taking control over their learning journey. This paper presented the premises of applying personalised learning in two distinct case studies, concerning informal and inquiry-based learning respectively.

The lessons learned from the informal learning case study of the ROLE project have provided us with an insight into some of the challenges associated with the deployment of PLEs for supporting informal learners in the context of using and manipulating OER. Building on these lessons, we plan to proceed with the deployment of PLEs in the inquiry-based learning context of the weSPOT project, in order to further explore the challenges and opportunities of personalised and self-regulated learning. The overall lessons learned from investigating these two different case studies and learning contexts will enable us to formulate a set of best practices regarding the successful implementation and deployment of PLEs for supporting SRL both in informal and formal education settings.

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How and When Presenting a Concept Map for Learning and an Accurate Self-evaluation?

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Keywords: Self-regulated Learning, Self-evaluation, Concept Map, Cognitive Load.

Abstract: Self-evaluation is not an easy step for learners even if it is a decisive step in self-regulated learning. The goal of our study was to test concept maps effect on learning performance and self-evaluation accuracy. 136 students were assigned over five experimental groups in which the format used (consultation/construction) and the moment of use (simultaneous of the learning task vs. after the learning task) of concept map varied. Cognitive load was also measured in order to explain differences in performance and self-evaluation. Results suggested that participants in the consultation conditions have a more accurate self-evaluation and better performance than participants in the construction condition. More studies are required to identify more precisely what factors influence the efficiency of use conceptual map.

1 INTRODUCTION

Self-evaluation is a process which consists in detecting a difference between a specific learning goal and the current state of knowledge (Nelson & Narens, 1990). The accuracy of this estimation is essential because this is what enables learners to adopt the appropriate learning strategies and behaviours (Gama, 2004). However, numerous studies show that students experience difficulties to perform a correct self-evaluation (see Dunlosky and Nelson, 1994; Dunlosky & Nelson, 1992; Koriat, 1997).

Several tools have been developed in order to improve self-evaluation accuracy (Dunlosky and Rawson, 2012, Kornell and Son, 2009, Chi and al., 1989). However, their uses are specific (for definitions or for a well-guided condition) or their efficacy limited. More recently, Redford et al. (2012) have improved self-evaluation of comprehension by the aid of concept maps. Concept maps are schemas which display the relations between different concepts (see Nesbit and Adesope, 2006; Novak & Gowin, 1984).

According to Redford and his colleagues, learners who organize information themselves would exhibit a more accurate self-evaluation as compared to learners who merely consult an already defined map. Results of their experiments confirm this hypothesis by highlighting that self-evaluation is more accurate in the construction condition as compared to the rereading condition (Experiment 1) and to the consultation condition (Experiment 2). Thus, for the authors, presenting the same information twice does not enhance self-evaluation accuracy.

The Cognitive Load Theory (see Sweller, 1988) casts a new look at this lack of effect of concept map consultation. In particular, the “split attention effect” can offer explanations to this result. This “split attention effect” appears when people have to process different information for which the integration needs to be mentally performed in order to infer sense from the presented material (Tricot, 1998).

In parallel, in the Information Processing Theory perspective, Winne (2001) shows that self-regulated processes including self-evaluation, rely on cognitive resources. Thus, map consultation, learning and self-evaluation have a cognitive cost and the concurrent fulfilment of these three activities may overload learners’ working memory, resulting in a bad integration of information and in difficulties to perform self-evaluation. On the contrary, the map construction condition involves only one source of information. Cognitive load of participants is consequently less important, which allows them to use all their resources to process, to integrate information but also to evaluate this degree of integration more easily.

Taken together, these studies (Redford et al, 2012; Tricot, 1998) suggest implicitly the issue of temporality in the presentation of concept maps in their effectiveness vis-à-vis self-evaluation and learning. Therefore, in this perspective of temporality, it is relevant to examine whether the construction and the consultation cannot be more efficient for learning and self-evaluation whether it is done after rather than during the learning task.

To answer this question, we based our experiment on Redford et al's (2012) study in which students had to construct or to consult a concept map during a learning task. We added two new conditions. The first condition was a consultation of a pre-conceived map after seeing a learning content (and not during). The second one was a construction condition after seeing a learning content. We added also a control condition in which no concept map was used at all. The learning task was word-processing and especially creation of styles.

In reference to the Cognitive Load Theory (Sweller, 1988), we predicted that learning would be better and self-evaluation more accurate for participants who use concept maps after the learning task as compared to participants who use concept maps during the learning task. In addition, we predicted that participants who construct the concept map would perform better and will have a more accurate self-evaluation than participants who merely consult the concept map.

In other words, organizing information oneself instead of just reading it would improve participants' learning. Indeed, concept map elaboration is a deep cognitive strategy (e.g., Weinstein and Mayer, 1986). Numerous authors (e.g., Pintrich and De Groot, 1990; Weinstein and Mayer, 1986) have highlighted that the use of deep strategies lead to higher performance and to a more accurate self-evaluation (e.g., Cassidy, 2006).

Finally, we expected an interaction effect between both, the modality and the time of map presentation. Thus, we predicted that the "concurrent consultation" condition would lead to the worst performance and to the less accurate self-evaluation whereas the "construction after the learning task" would lead to the best performance and to the more accurate self-evaluation.

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2 METHOD

2.1 Participants

136 students (80 females, average age = 18.5, SD = 1.2) in first year of "Industries and Administration Management". No differences in the initial level of knowledge on word-processing were detected among the experimental groups ($p > .05$).

2.2 Familiarization Phase with Concept Maps

The familiarization phase was intended to introduce students to the "concept maps" designer tool that they would handle during the learning phase. Students were presented a screencast (screen + audio commentary) with the following information: the purpose and terms of the experiment, the definition of a concept map and its purpose, an example of concept map and how it should be read, the function and value of a concept map and a demonstration of the use of the concept maps designer tool. Then they had to do two training exercises including a feedback with examples of conceptual maps of the expected kind and of the inadequate kind. The tool used to build concept map was a simplified version of CoGui (http://www.lirmm.fr/cogui)

2.3 Learning Phase and Groups

The learning phase consisted of three videos. These videos all related to word processing and more specifically on how to create "styles" (with a word processor) and apply them to the document. The videos had an increasing level of difficulty. The software device was constructed so that learners cannot avoid any part of the videos or view them in a different order than the one proposed. During this learning phase, participants were randomly assigned in one of the five groups depicted as follows in the learning phase. The first group was instructed to watch videos and simultaneously build a concept map (N = 27). The second group was instructed to watch the videos and then build a concept map (N = 28). The third group watched the video and simultaneously consulted an expert conceptual map data (N = 27). The fourth group was viewing videos then consulted an expert concept map (N = 24). Finally, the fifth group (control group) was viewing videos simply without being presented concept maps (N = 30).

Three important instructions were given to each participant: the opportunity to "pause" the videos at any time, they were not allowed to watch video twice and to take notes. Participants were also informed that they will later undergo a test to assess their understanding: Test Phase and self-evaluation

2.3.1 Familiarization with Exercise Test

The exercise test itself was preceded by a familiarization period to enable to have a clear idea of what they would be asked to do.

The familiarization period (identical to the test) consisted of the three following steps:

- A performance prediction ("To what extent do you think you can correctly answer the following question?")
- Task instructions and execution ("You will be prompted to format the text without using styles")
- A post diction ("To what extent do you believe you have correctly answered the previous question?")

2.3.2 The Test

The exercise test consisted of the same three steps as the familiarization period. More specifically, during the task execution, participants were instructed to change the appearance of a text using styles. To do this, they first had to change the predefined styles according to specific instructions in 15 actions. One point per correct action was attributed. For measuring self-evaluation, participants answered on a scale ranging from 0 to 100. They estimated before and after the exercise how they thought they could or had correctly answered the question.

2.3.3 Self-evaluation Biases

Biases were measured by the difference between the actual performance of learners and their performance evaluation. For this, we used a linear regression analysis (Bouffard et al., 2006). First, we transformed the performance scores and measures of self-evaluation in Z scores. Then, we performed a regression of performance on self-assessment for standardized residuals. Standardized residuals equal to or greater than 1 indicated over-evaluation and standardized residuals equal or less than -1 indicated under-evaluation.

2.4 Measure of Cognitive Load

To measure cognitive load, we used the distinction done by Amadieu, Mariné and Laimey (2011) who measure cognitive load in two different ways. Specifically, the authors distinguish general cognitive load and cognitive "overload". For example, to measure cognitive load associated with the general understanding of the videos, participants were asked to rate on a 9-point scale: "The cognitive effort to understand videos was:" very small (1), very important (9) (Paas, 1992). To measure cognitive "overload", participants asked to rate on a 9-point scale: "Indicate how much it was difficult for you to understand videos", very easy (1), very difficult (9). The same questions were asked to measure the cognitive load associated with consultation / construction of concept maps.

2.5 Procedure

The first two phases of the device were identical for all participants. The first phase measured the level of knowledge of participants before any learning; the second one was to familiarize participants with the concept maps. In the third phase, called learning, students were assigned randomly to one of five groups of our experimental manipulation, watched the learning videos and then did the familiarization and test exercises. At the end of the experiment, all participants responded to questions measuring cognitive load.

3 RESULTS

3.1 Performance

A one-way analysis of variance (ANOVA) was conducted with group as the independent variable and with performance as dependent variable. Results showed a significant effect of the group, $F(4, 131) = 2.72$, $p = .03$, $\eta^2p = .08$. Post-hoc test (Tukey) detected a significant difference between the control group and the simultaneous construction group, $p = .04$, showing that the control group ($M = 10.6$) performed better than the simultaneous construction group ($M = 6.0$). The other groups did not significantly differ between them.

A two-way ANOVA excluding control group, was conducted in order to detect eventual interaction effect between modality and moment. Results detected an effect of modality on performance, $F(1, 102) = 5.54$, $p = .02$, $\eta^2p = .05$. Participants in the consultation group ($M = 9.8$) performed better than participants in the construction group ($M = 7.0$). Neither moment effect nor interaction effect was found.

3.2 Measure of Self-evaluation

3.2.1 Prediction Biases

In order to detect biases differences between our five groups, a one-way ANOVA was run on standardized residuals that detected a main effect of the group, *F*(4, 130) = 3.00, $p < .05$, $\eta^2p = .08$. Post-hoc test (Tukey) detected a significant difference between the delayed construction group and the simultaneous construction ($p < .05$) showing that participants in the delayed construction group tended to overestimate their performance while participants in the simultaneous construction tended to underestimate their performance (Table 1). Moreover, participants in the control group tended to underestimate their performances while participants in the delayed construction group tended to overestimate their performance ($p < .05$).

A two-way Moment x Modality ANOVA detected an interaction, *F*(1, 102) = 4.63, $p < .05$, $\eta^2p = .04$. Whatever the moment, consultation conditions enabled an accurate self-evaluation in both the delayed and the simultaneous condition. Simple effect analysis showed that mean bias did not differ between both consultation conditions. However, participants tended more to over-evaluation in the delayed construction condition than to under-evaluation in the simultaneous construction condition, *t*(53) = 2.39, $p = .02$.

3.2.2 Post-diction Biases

One-way ANOVA run on standardized residuals of post diction detected a main effect of the group, *F*(4, 130) = 2.23, $p = .05$, $n^2p = .07$. Post-hoc test detected a marginal difference ($p = .06$) between the delayed construction group and the simultaneous consultation group, suggesting that participants in the delayed construction group tended to overestimate their performance while participants in the simultaneous consultation group tended to underestimate their performance (see Table 1).

Two-way ANOVA only detected an effect of the moment of presentation, *F*(1, 102) = 4.17, $p = .04$, $\eta^2p = .04$, showing that the delayed condition led to a higher evaluation while the simultaneous condition led to a lower evaluation. Interestingly, participants for whom self-evaluation was the more accurate were those in the delayed consultation condition. Neither modality nor interaction effect were found.

Table 1: Descriptive statistics means (and standard Deviation) of standardized residuals of self-evaluation bias.

Groups	N	Prediction	Post-diction
DConstr	28	.43 (1.05)	36 (.92)
SConstr	27	-.25 (1.08)	-.14 (.90)
DConsult	24	-.08 (.91)	.01(1.14)
SConsult	27	.07 (.97)	.33(1.14)
Control	30	-.18 (.87)	.09 (.81)

Note: D for Delayed; S for Simultaneous; Constr for Construction; Consult for Consultation.

3.3 Cognitive Load

3.3.1 Mental Load

A one way ANOVA with group as factor and mental load to videos understanding as dependent variable was computed. Results showed a significant group effect *F*(1,131) = 6.97; $p < .001$; η^2p =.18. Post-hoc test (Tukey) detected a significant difference between delayed construction group and all the other four groups. The analysis showed that the mental load to understand videos was lower for participants in the delayed construction group than for the other groups.

A Modality x Moment ANOVA performed on mental load to videos understanding showed an effect of the modality *F*(1, 102) = 2.56, $p <.05$, η^2p =.11, an effect of moment *F*(1, 102) = 18.31, $p <.001$, η^2p =.15 and an interaction effect, *F*(1, 102) = 5.97, $p < .05$, $\eta^2p = .055$. Simple effect analysis showed that the mental load to understand videos was less important for participants in the delayed construction group (*M* = 2.86) than for the participants in the delayed consultation group (*M* = 4.46), *t*(50) = -2.61, $p < .01$. Moreover, the mental load was lower for the participants in the delayed construction group (*M* = 2.86) than for the participants in the simultaneous construction group (*M* = 5.52), *t*(53) = -5.29, $p < .001$.

Same analysis was conducted with the mental load felt to construct/consult the concept maps and detected an interaction effect between the two factors, *F*(1, 102) = 7.35, $p < .01$, $\eta^2p = .07$. Simple effect analysis showed that when the map was used in a delayed way, participants in the construction group felt a mental load significantly less important (*M* = 2.18) than participants in the consultation group (*M* = 4.42), *t*(50) = -4.34, $p < .001$. Analyses also showed, that participants felt a less important mental load when the construction was done in a delayed way (*M* = 2.18) than when the construction was done in a simultaneous way (*M* = 4.56), *t*(53) = -5.99, $p < .001$.

Finally, for all participants, the cognitive load felt to understand videos was negatively correlated with the performance, $r = - .21$, $p < .05$, with the prediction, $r = -.31$, $p < .001$ and with the post diction, $r = -.29$, $p < .001$. The cognitive load felt to construct/consult maps was negatively correlated with the performance $r = -.24$, $p = .014$, and marginally with the post diction, $r = -.18$, $p = .072$.

3.3.2 Mental Overload

A one-way ANOVA with group as factor and mental overload to videos understanding as dependent variable was computed. Results showed a significant group effect *F*(1, 131) = 7.38; $p < .001$; $\eta^2 p = .18$. Post-hoc test (Tukey) detected a significant difference between delayed construction group and all the other four groups. The analysis showed that the mental overload to understand videos was lower for participants in the delayed construction group than for the other groups.

A Modality x Moment ANOVA performed on mental overload felt to understand learning videos found significant effect of modality *F*(1, 102) = 6.08, $p < .05$, $\eta^2 p = .06$, an effect of moment *F*(1, 102) = 8.20, $p < .001$, $\eta^2 p = .07$ and an interaction effect, *F*(1, 102) = 15.62, $p < .001$, $\eta^2 p = .13$. Simple effect analysis showed that participants in the simultaneous consultation group felt a less important mental load (*M* = 4.85) than the participants in the simultaneous construction group (*M* = 5.89), *t*(52) = 2.27, $p = .03$. Analysis also showed that participants in the delayed construction felt significantly a less important mental load (*M* = 4.96) than participants in the simultaneous construction (*M* = 5.89), *t*(53) = -2.11, $p = .04$.

Finally a Modality x Moment ANOVA conducted on mental overload felt to construct/consult concept maps showed a significant interaction effect, *F*(1, 102) = 6.67, $p < .05$, $\eta^2 p = .06$. Simple effect analysis showed that participants in the simultaneous consultation group felt a significantly less important mental overload (*M* = 4.30) than participants in the simultaneous construction group (*M* = 5.89), *t*(52) = 3.35, $p < .001$.

The difficulty felt to understand videos was negatively correlated with the performance, $r = -.23$, $p = .01$, with the prediction, $r = -.41$, $p < .001$, and with the post diction, $r = -.20$, $p = .02$. Similarly, cognitive overload felt to construct/consult maps was negatively correlated with the performance $r = -.23$, $p = .02$, with the post diction, $r = -.27$, $p = .01$, and was marginally correlated with the prediction, $r = -.19$, $p = .06$.

4 CONCLUSIONS

The aim of this study was to determine what the condition concept maps' presentation is the most relevant for learning and self-evaluation. Our first hypothesis assumed that concept maps construction would allow learners to have better learning performance and self-evaluation as compared to those who had to consult concept maps. Secondly we assumed that using a map after the learning task would be more efficient than using a map during the learning task. Finally we supposed that the "concurrent consultation" condition would lead to the worst performance and to the less accurate self-evaluation whereas the "construction after the learning task" would lead to the best performance and to the more accurate self-evaluation.

Results contradict the first and the third hypothesis and did not confirm the second one. Indeed, they showed that the consultation conditions were more efficient to improve learning and self-evaluation accuracy. More specifically, construction conditions decrease performance and self-evaluation accuracy as compared to the control group.

Regarding the cognitive load and overload, we thought that a higher cognitive load in the simultaneous and /or consultation conditions could explain lower performance and more inaccurate self-evaluation. This hypothesis is confirmed because participants found easier to understand videos when they had to construct a map rather than they had to consult it. Nonetheless, this is only right when map were used after the learning task. However, learners found easier to consult simultaneously a map than construct it simultaneously. These results confirm Stull and Mayer (2007) results. According to these authors, construction condition adds a task to the learning and cognitively overloads learners.

Moreover, these results are in contradiction with previous study (see Redford et al., 2012). They might be explained by the fact effective simultaneity between maps and videos was difficult to reach.

Finally, regarding to the cognitive load felt by learners, it could be relevant to check the concept map quality and numbers of created links. This point could explain why learners found easier to understand videos when the have to construct a map.

To conclude, we can recommend to not overloading learners as they are learning and this by limiting the tasks number during learning; present help system as concept map not during learning, and privilege the maps consultation rather than the maps construction.

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Tweedback: A Live Feedback System for Large Audiences

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Keywords: Feedback, Live Feedback, Lecture, Peer Instruction, Chatwall, Web Application.

Abstract: Live feedback systems have been proven to be suitable for teachers' needs. Especially in classes with a lot of participants feedback in an electronic form can create additional value by getting feedback from all students. The live feedback system Tweedback incorporates three feedback possibilities. One form of feedback is Peer Instructions to test people's knowledge using multiple choice questions. Additionally the possibility for students to rate the teachers' Speech Parameters could improve the lecturers course value. Furthermore the ability to ask questions anonymously could lower the threshold for students and may result in a better understanding.

1 INTRODUCTION

Nowadays students often use mobile devices, such as smartphones or tablets, during a lecture to communicate with each other. This offers an opportunity to use mobile devices as a new communication channel between a teacher and her students.

Often teachers want to check students' understanding of a previously explained issue, for example the functionality of a complex concept in computer science or the diagnose of a patient's symptoms in medicine. Asking a small group of students is feasible, but asking a larger group can be very inconvenient, where this may lead to turmoil in class and will often be focused only on a small number of participants. There are solutions, which utilize a remote control to allow the students to choose predefined answers (for example ”Qwizdon Q5” (Qwizdom Ltd, 2012), ”Powervote” (Powervote, 2013) or ”voting4life” (Art4live GmbH, 2013)). This simplifies this proposal to ask a large group of students. Imagine a medical course, where the lecturer describes the symptoms of a disease. The lecturer then frames four possible diseases as answers and each student has to vote for one.

Solutions for this kind of feedback, which use an extra device, are on the one hand very comfortable. The usage is simple for both, students and lecturers, so there is no need for an extra explanation. On the other hand there are a lot of disadvantages. All devices have to be maintained by replacing empty batteries, keeping them clean, retaining them and ensuring they are complete in quantity and quality.

To avoid these disadvantages, another possible solution is to use the mobile devices, the students own already. By using their own devices, a lecturer could ask a question to a large group of students without providing extra devices.

All in all there are three different types of feedback, which will be explained in the following. All three types have the possibility in common to get live feedback. Live feedback means the ability of getting instant feedback from a large group of people in a classroom scenario. Our goal is the implementation of a tool, that allows teachers to use all three types of live feedback in their lectures, without having to care about technical details.

The previously presented scenario describes the Peer Instruction concept (PI), where ”the instructor presents students with a qualitative (usually multiple choice) question that is carefully constructed to engage student difficulties with fundamental concepts. After that the students consider the problem on their own and contribute their answers in a way that the fraction of the class giving each answer can be determined and reported.” (Redish, 2005)

The second type of live feedback is the Chatwall (CW), also known from facebook.com and twitter.com. Students have the possibility to ask questions and are able to vote for other students' questions to make them more important. Then the lecturer can use this information to clarify obstacles. This concept is very similar to the backchannel idea, first mentioned by the research group of Franois Bry. (Gehlen-Baum et al., 2012)

Whereas the Peer Instruction concept and the

Chatwall/Backchannel have been well-known for several years, the third kind of live-feedback is not yet popular and has not yet been fully investigated. The main idea is that the students are able to mark a single Speech Parameter as inconvenient. The talking speed is for example a possible Speech Parameter. By giving the audience the ability to mark the talking speed as too fast, the lecturer can reduce her talking speed to improve the comprehensibility.

All three kinds of live feedback are presented in detail in the following chapter. After that we define the functional and nonfunctional requirements of a general live feedback system. In the following we present our architecture and illustrate design decisions we made for Tweedback to fulfill these requirements. The last chapter summarizes all the work we have done and outlines our future work.

2 STATE OF THE ART

As previously mentioned, there are three kinds of live feedback. This chapter overviews existing solutions, which either implement one kind of live feedback or a composition of two or more. We introduce first the implementations of the Peer Instruction concept and then a solution for giving feedback based on a lecturer's Speech Parameters.

The University of Paderborn realized the Peer Instruction concept as a closed-source web application called PINGO (Reinhardt et al., 2012). They built an application that is accessible on any device, mobile or not. Using this application a lecturer, who must have an account at the University of Paderborn, can add surveys during the lecture. A survey thereby exists of a multiple choice question. The participants, mostly students, do not need to have an account and answer anonymously to the lecturer's questions. It is not possible to add free text questions and the source code is not open.

The Peer Instruction concept is also realized as a prototypical web application (University of Rostock, 2012) at the University of Rostock. Thereby the focus is rather on the usability and performance than the stability. So this application has a minimalistic user interface and thus provides maximum compatibility with mobile devices.

One solution, that also handles just a single kind of live feedback has been developed at the University of Freiberg and is called myTU (Technische Universität Bergakademie Freiberg, 2012). It is available for the mobile operating systems Android and iOS. It is more a manager for student's life than instrument for live feedback, but students can use it to rate the speed of lecturer's speech.

Combining a Chatwall and the ability to rate the lecturer's Speech Parameter is the idea behind the web application Backstage (Gehlen-Baum et al., 2012), developed and researched by F. Bry. Backstage was designed to investigate the use and the design of a digital backchannel by implementing a prototype that looks and acts like twitter, but is used for a lecture. The students may ask questions to the whole audience, including the lecturer. The lecturer also may ask questions to the students using Backstage. Backstage is focused on large classes, but is used only with a small number of students for the experimental studies (approx. 20 students). Due to its design using a synchronous Java web server as Jetty, it may be slow under heavy use with multiple large lectures (more than 100 participants) in parallel.

A project, which is most similar to our approach is called SMILE 2.0 (Feiten, 2012). It has been developed by the University of Freiburg and allows students to ask free questions and rate the lecturer's Speech Parameters using a social platform. Furthermore it has the functionality of a Peer Instruction application. Unfortunately it is not open, neither to use nor the source code, so we could not evaluate it.

Our goal is a composition of different types of live feedback, namely PI, CW and SP.

3 AIMS AND REQUIREMENTS OF TWEEDBACK

The major aim of our system is to enable feedback for students and give lecturers the possibility to react on the feedback in time. Especially in large classes verbal one to one communication with many people is not feasible. Here feedback systems can assist the teacher.

3.1 Functional Requirements of Live Feedback System

Feedback can be given in different ways. We concentrate on three categories. The first functional requirement is Peer Instruction (PI). Teachers should be able to start surveys ad-hoc in lecture or start prepared ones. A survey is implemented as a multiple choice question. Results of these surveys should be accessible for the lecturer at all time.

Besides Peer Instruction, students have additional possibilities to give feedback regarding the content of course and form of presentation. Speech Parameters (SP) can be rated throughout the lecture. Example categories are speed and understanding. A threshold regulates how many votes are needed in a given period of time to notify the lecturer. The teacher will be notified on a small screen about the current situation.

The third functional requirement, called Chatwall (CW), is feedback in form of asking particular questions, rating and answering them. For lecturers it is hard to give a presentation and read questions from the audience at the same time. Therefore an unfiltered forwarding of audience questions will not be convenient. The system gives the audience the possibility to ask questions on a Chatwall-like platform. At the beginning questions are proposed and displayed only on students' devices. After questions have been proposed others can vote for these. This can result in high rated questions concerned by many others. A threshold decides which question will be presented to the lecturer. A log of the Chatwall can also be used by the lecturer afterwards to evaluate his presentation.

3.2 Non-functional Requirements

Besides the functional features as described above, Tweedback has many other requirements which aim best possible user experience. First of all, interaction with the system has to be fast and responsive. Waiting while interacting with the application is decreasing acceptance of users. A second requirement with direct impact on acceptance rate is an intuitive and minimalistic user interface, that even fits on very small mobile devices. Tweedback will be used by many laypersons. According to (N)ONLINER Atlas 2012 (Initiative D21 e.V., 2012), which represents the situation in Germany, 96.9% of young people (20–29 years) have Internet experience. So we can assume that they are able to use even complicated websites. According to the lecturer's view, it is assumed that teachers have less experience with the Internet (e.g. 60–69 years, 60.4%). We do not know what people will use our system in the future, how old they are or what preferences they have. So we cannot suppose that teachers are familiar with complex websites and their navigation features. According to the students' side it can be assumed that there is more experience in dealing with complex websites due to the age of students.

Students use their mobile devices to access Tweedback. It is not possible to control which device will be used. This is a design decision. The advantage is that users maintain their own devices. The disadvantage is that the interface of a live feedback system needs to be as flexible as possible on students' devices.

With a growing number of users the system needs to be scalable. This is especially a matter of concern when many surveys start at the same time. In these cases many students take part at a survey simultaneously. This causes an access peak. Situations with thousands of connections need to be handled.

For users we want to make the first step of participation in Tweedback as easy as possible, which leads to an anonymous access for students. We do not want users to pass an initial account creation procedure. We believe in success of open systems.

To generate additional value compared to ”offline“ feedback, users can not be blamed for wrong answers. It is a common phenomenon that people do not participate in surveys because they are afraid to say wrong answers in the front of others. But these people are able to participate in a feedback system when users are anonymous. This is the second reason why anonymous access is preferred.

Finally the system has to be modular to easily implement new forms of audience interaction in the future.

4 ARCHITECTURE OF TWEEDBACK

In order to provide an application for many mobile devices, it is sensible to build a web application that simply serves HTML. Because most mobile devices are able to render HTML5, Javascript and CSS, there is no need to develop a native app for all the mobile operating systems (namely the most common used: Android, iOS and Windows Phone) (Kamboj and Gupta, 2012). By using just one browser-related client interface, we do not have to manage and maintain multiple different platform variants. Even if there are frameworks that promise to handle these issues, there would always be multiple different code repositories. This would unnecessarily increase the development effort and support.

Furthermore the user interface shipped by the web application should not only fit on most kinds of screens (for example on a mobile device and/or a notebook), but it should be easy to use, too. While the first can be assumed by using a well-known framework for web user interfaces, the last is hard to achieve. Our approach is to use the bootstrap framework from twitter. It provides a set of common user interface elements, such as a header bar or a button, and organizes the way it is visually structured. Additionally we want to subdivide the user interface into different views, in such a way that each feature has its own view. Offering the lecturer a choice of features, students are able to see which feature is enabled by recognizing which view is currently activated. A feature implements one of the previously explained functional requirements, namely the Peer Instruction, the Chatwall and Speech Parameter.

To implement anonymousness there has to be a concept to ensure that a lecturer can not trace back the students id. Technically we solve this issue by allowing everybody to participate. Nobody has to register herself or login with her university account. Another fact arises with the ability to be anonymous. It is maybe possible to manipulate the system by overusing a function or trying to distract the lecturer. We prevent such manipulations by defining certain thresholds and time locks. A student for example can not ask multiple questions at a short time (<1 second), so we disable her functionality to ask questions right after a question is asked.

Responsiveness and scalability are difficult to achieve, so we need sophisticated technologies to solve these requirements. Fortunately both can be handled at once by using an asynchronous web server working with two-way communication channel in tandem. Investigating in numerous solutions for asynchronous web servers, we decided to use the tornado web server, developed by facebook. It is event-based, well-known for stability and very good performance. It is possible to handle more than 5000 connections simultaneously on commodity hardware. A two-way communication channel is necessary, because both, the server and the client, have to send messages to each other. The client hereby is the browser, of the lecturer as well as of the students. Imagine for example the use of the Chatwall, where one student asks a question. To view this message to all the other students, it has to be delivered to their browsers. Here the student's browser sends the question to the server. Then the server has to push this message to all the other students (and lecturers maybe, too) browsers. Without the use of a two-way communication this would not be possible.

We plan to use the library socketIO as the two way communication layer. It makes use of WebSockets, defined in HTML5. Furthermore, it is well implemented for Javascript and for the tornado web server. Additionally, it has several fallbacks for browsers not supporting Websockets. These fallbacks make use of AJAX to emulate a two-way communication over HTTP 1.1.

Figure 1 summarizes the technology stack previously presented. All permanent data will be stored in a non-relational database, because there is a flexible scheme necessary to develop this web application.

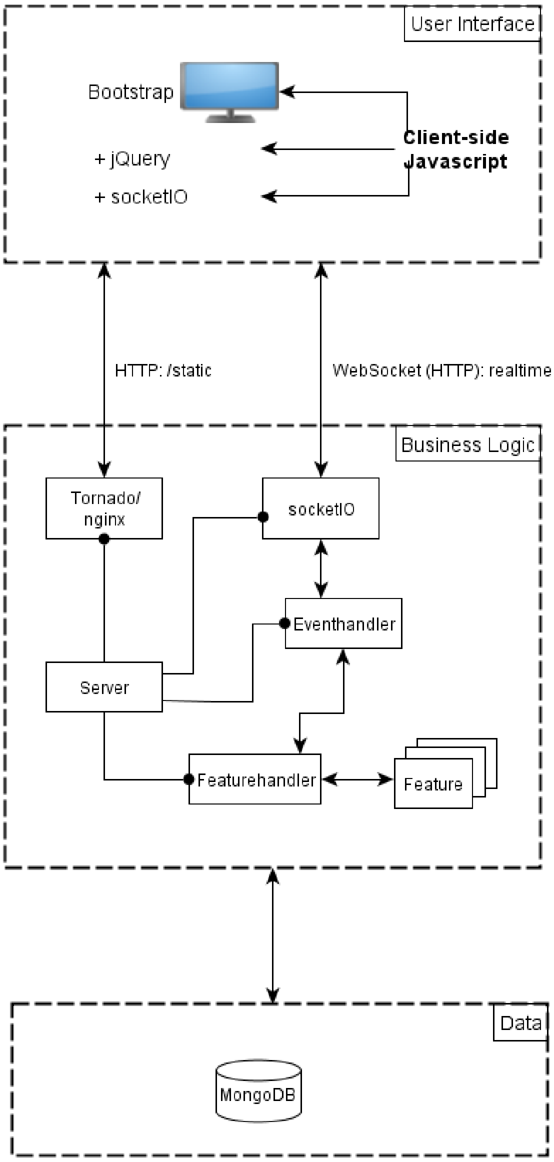

Figure 1: Technology Stack.

5 CONCLUSIONS

Many people have mobile devices for communicating with others or simple Internet browsing. These devices can be used to give feedback within large classes. The presented live feedback system Tweedback uses these mobile devices. People can give feedback in one of three ways: Peer Instruction, Chatwall or rating Speech Parameters. Besides these functional requirements the feedback system has to be fast and responsive, easy to use by laypersons, compatible to many mobile devices and scalable. These requirements are accomplished with user interface frameworks for mobile web which assure compatibility to most user devices. Event-based asynchronous communication is used for scalability and anonymous access is allowed to assure an easy participation and to give users the chance to give feedback which they would have refused in front of many other people.

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Activities and Trends Analytics in a Widget based PLE using Semantic Technologies

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Abstract: We report about work in progress on tracking the activities and trends of users from logs in a widget based Personal Learning Environment (PLE) using semantic technologies and standards for retrieval. As input for the observations, we are using the data from our self developed PLE with around 4000 active users. Last two years we logged their activities and modeled them with RDF (Resource Description Framework)* as base for improvement analysis of existing system. The main objective of this work is to outline how learning environments like PLE can benefit from Semantic Web and its contribution for such efforts like analytics, profiling, recommendations and usability.

1 INTRODUCTION

Emergence of the Web 2.0 (O'Reilly, 2005) introduced participation of users as part of the web. The transformation of internet from consuming into interaction medium goes hand in hand with the advances of the web technologies. These changes also influences how we think, inform ourselves, organize our everyday activities but also how we learn. Several research studies have been carried out to analyze how Web 2.0 applications such as Blogs (Farmer, 2005; Holzinger et al., 2009; Ebner et al., 2007), Wikis (Augar et al., 2004), Podcasting (Towned, 2005) as well as Microblogs and Social Networks generally(Ebner and Maurer, 2009; Ebner et al., 2010a) influence users and can enhance education. Various studies on Web 2.0 usage amongst students (Ebner and Nagler, 2010) outline how hard it is to follow the trends and even more to monitor them in an appropriate way. Mashups (Tuchinda et al., 2008) and personalization can be used to manage this challenge in learning environments. Nowadays, with increasing number of smart phones the online presence is getting more intensive for a huge population of users. They share different resources and contribute to the Web with their mobile devices. This trend applies also for teachers and learners in context of E-Learning (Ebner et al., 2008). Those activities consider also Web 2.0 applications and services raised like YouTube (for sharing Videos), Flickr (for sharing pictures), Slideshare (for sharing presentations), Scribd (for sharing documents), Delicious (for sharing bookmarks) etc. The huge amount of such applications and their usage in learning and teaching has changed the online behavior and attitude of learners in respect to the new arising technologies (Downes, 2005). This led to the idea of Personal Learning Environment (PLE), where tiny applications (widgets) can be integrated and combined within a learning environment managed by the learners according to their actual personal needs. Such approach resembles to the mobile application environments in many ways, i.e. a widget store is offered where the learners can install widgets on one or many spaces or personal desktops. Due to the fact that mobile technologies and social web are available ubiquitously as well pervasively used, they have influence our every day life and learning environments (Holzinger et al., 2005; Klamma et al., 2007). It is quite challenging for education not to be overwhelmed by all these various opportunities within a learning environment. Todays learning process became more individual, multi facetted and activity driven with the tendency to ad-hoc initiated collaboration and information exchange. All these parameters increase the complexity of online learning platform design and organization. Dynamics involved in this process require nowadays shorter optimization cycles in adaptation process of Learning Management

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*http://www.w3.org/RDF/

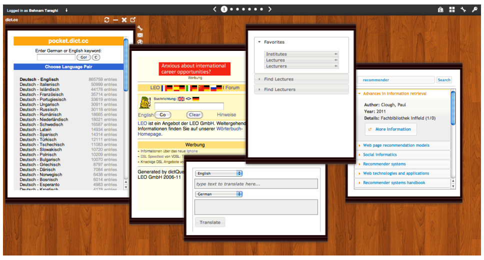

Figure 1: PLE Desktop at Graz University of Technology.

Systems and Personal Learning Environments. In order to provide the learners an attractive surrounding and to tackle the named problems use of learning analytics regarding activities and trends for optimization of learning process and design of learning surrounding emerges as the time passes by. Such data contributes to the personalization and adaptation of the learning process and belonging hosting environments. For these purposes we logged in anonymous way user data regarding activities on widgets in our PLE for last two years and modeled them into learning context using RDF in order to generate statistics that would help us to improve the concept of the widget based PLE. For querying the the context we used semantic retrieval standard SPARQL[2].
In following sections we will offer a short overview over related work and explain how we managed to model the activities in order to track them. We will also show some preliminary results on current production system. This paper will be concluded by the discussion about the first results and some future work announcements.

2 RELATED WORK

The main idea of using and developing a widget based PLE at Graz University of Technology[3] was to combine and integrate existing university services (Ebner and Taraghi, 2010) as well as resources and services on the World Wide Web in one platform and in a personalized way (Ebner and Taraghi, 2010). It bases on meshup of widgets (Taraghi et al., 2009a; Taraghi et al., 2009b; Taraghi et al., 2009c) that represent the resources and services integrated from the World Wide Web within the PLE. On the other hand Web provides lots of different services; each can be used as supplement for teaching and learning. The PLE has been redesigned in 2011, using metaphors such as apps and spaces for a better learner-centered application and higher attractiveness (Ebner et al., 2010b; Taraghi et al., 2012). A sample of PLE Desktop with Widgets can bee seen in figure 1. The PLE has been running since two years. In order to enhance PLE in general and improve the usability as well as usefulness of each individual widget a tracking module was implemented (Taraghi et al., 2011). Different works outlined the importance of tracking activity data in Learning Management Systems (Santos et al., 2012; Verbert et al., 2011). None of them addressed the issue of intelligently structuring learner data in context and processing it to provide a flexible interface that ensures maximum benefit from collected information. The Semantic Web standards like RDF and SPARQL where data is structured and queried as graphs and projected on specific knowledge domain using adequate ontologies has been fairly successful used to generate correct interpretation of web tables (Mulwad et al., 2010) to advance the learning process (Prinsloo et al., 2012; Jeremić et al., 2012) as well to support the controlled knowledge generation in E-learning environments(Softic et al., 2009). The retrieval standard provided by Semantic Web named SPARQL enables easily querying of semantically enriched data. This potential was also recognised by current research in the EU project Intelligent Learning Extended Organisation (IntellLEO)[4] which produced in the published ontology framework: ActivitiesOntology[5] to model learning activities and events related to them along with the surrounding environment and Learning Context Ontology[6] which offers formalization of learning context as general learning situation. Due to their accuracy to the problem that is addressed by this work these ontologies have been used to model the context of analytic data collected from user logs in this work. Our method is based on a tracking model as a knowledge domain related context using ontologies and query languages like SPARQL similar to current research in the area of Self-regulated Learners(SRL)(Jeremić et al., 2012). Exploratory graphics show that the sum of (web) user data on the access paths and the linkage of the resources within an environment(site) at a particular time window gives sufficient insight at what constitutes relevance; important properties and linkages between data resources(Siadaty et al., 2011). The overall goal of is summarization of visualizations and evaluation of statistic data that enable the PLE optimization and present the research community used generic techniques and metrics for problems in design and adaptation of learning environments.

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[2] http://www.w3.org/TR/rdf-sparql-query/

[3] http://ple.tugraz.at

[4] http://intelleo.eu

[5] http://www.intelleo.eu/ontologies/activities/spec/

[6] http://www.intelleo.eu/ontologies/learning-context/spec/

3 ANALYTICS FROM LEARNERS LOGS

3.1 Modelling User Activities

The main objective for tracking is appropriate modelling since RDF offers only the framework how the data is aligned and organized in such constructions. This task concerns mostly the choice of the right vocabulary or ontology. A bunch of experience is usually necessary to complete such effort especially when ontology has to be designed on your own. In current research in *IntellLEO* EU project however this objective has been practically implemented. One of the main goals of this project according to the statement from project page is building an *innovative ontological framework for learning representation which includes learners, context and collaboration models, serving to achieve the targeted synergy*[7]. In the realm of the *IntellLEO* project inside the provided ontology framework two special ontologies are eminent for current work. The first is the Activity Ontology which offers a vocabulary to represent different activities and events related to them inside of a learning environment with possibility to describe and reference the environment (in this case PLE) where these activities occur. The second contribution from current Ontology research work in *IntellLEO* project is the Learning Context Ontology which describes the context of a learning situation. We used as it will be shown in following sections this Ontology to reflect the user activity context.

Formulation in listing 1 depicts an instance of `lc:LearningContext` class in compact N3 RDF Notation derived from our tracking module that stores them into a RDF Store and makes them accessible via relying SPARQL Endpoint. Translated into natural language this instance from listing 1 reflects that a `ao:Logging` event which tracked the learning activity of `ao:Viewing` by certain anonymous `um:User` inside the learning widget named *LatexFormulaToPngWidget* as `ao:Enviroment` at certain time point. As shown in this sample modeling example vocabularies and ontologies which fit appropriate for the special case can enable a high level of expressiveness in a very compact manner.

3.2 Querying of User Activities Trends

In order to retrieve the data relevant for the analytics RDF instances that reside in a RDF Store at our PLE environment SPARQL query language has been used. Operability over the data is much easier then in the case if the log data would be stored in specific structure without standardization. In this way we are able to answer the questions like ”Show me the a monthly activity intensity for year 2012?”. Listing 2 represents exactly the question stated in the manner of SPARQL syntax. The advantage of this approach is that data formulations are flexible and tolerant against any extension of representation schema, which means that adding supplementary properties would not change the expressiveness and retrieval of already existent information. Further since Semantic Web support the Open World Assumption (OWA), an answer whether or not is something reproducible out of the knowledge base is guaranteed.

Listing 1: Sample model of a learning context in N3 notation.

```
@prefix ao: <http://intelleo.eu/ontologies/activities/ns/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix lc: <http://www.intelleo.eu/ontologies/learning−context/ns/> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf−schema#> .
@prefix um: <http://intelleo.eu/ontologies/user−model/ns/> .

<https://ple.tugraz.at/ns/activity/#Viewing>
    a ao:Viewing .

<https://ple.tugraz.at/ns/users/#FSKSN>
    a um:User;
    foaf:name ”FSKSN” .

<http://ple.tugraz.at/ns/events/log/#7912>
    a ao:Logging;
    ao:performedBy <https://ple.tugraz.at/ns/users/#FSKSN>;
    ao:timestamp ”2012−10−04T07:52:52” .

<https://ple.tugraz.at/ns/widgets/#LatexFormulaToPngWidget>
    a ao:Enivironment;
    rdfs:label ”LaTeXFormulaPNG Converter” .

<http://ple.tugraz.at/ns/learningcontext/#7912>
    a lc:LearningContext;
    lc:activityRef <https://ple.tugraz.at/ns/activity/#Viewing>;
    lc:environmentRef
    <https://ple.tugraz.at/ns/widgets/#LatexFormulaToPngWidget>;
    lc:eventRef <http://ple.tugraz.at/ns/events/log/#7912>;
    lc:userRef <https://ple.tugraz.at/ns/users/#FSKSN> .
```

4 PRELIMINARY RESULTS

As preliminary result we are able to track the activity trends overall time periods like presented in figure 2. This violin graph depicts the visual answer of the query from listing 2. We can see that for year 2012 top three favored activities were ”Reading”,”Search” and ”Authoring” while activities like ”Quizzing”,”Computing”and ”Listening” are least frequent ones. Also the intensity shows that as expected that most activity happens at the beginning and at the end of academic terms when PLE is presented in introductory lectures to the newcomers and freshmen.

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[7] http://intelleo.eu/index.php?id=5

Listing 2: Querying the intensity of all activities in PLE after certain date.

```
PREFIX ao: <http://intelleo.eu/ontologies/activities/ns/> .
PREFIX foaf: <http://xmlns.com/foaf/0.1/> .
PREFIX lc: <http://www.intelleo.eu/ontologies/learning−context/ns/> .
PREFIX rdfs: <http://www.w3.org/2000/01/rdf−schema#> .
PREFIX um: <http://intelleo.eu/ontologies/user−model/ns/> .

SELECT ?actname, COUNT(?actname)
WHERE
{
 ?x rdf:type
     lc:LearningContext;
     lc:activityRef ?a;
     lc:eventRef ?e;
     lc:userRef ?u.

 ?e rdf:type
     ao:Logging;
     ao:timestamp ?date.

 ?a rdf:label ?actname;

   FILTER ( ?date > ”2012−01−01T00:00:00Z”ˆˆxsd:dateTime )
}
```

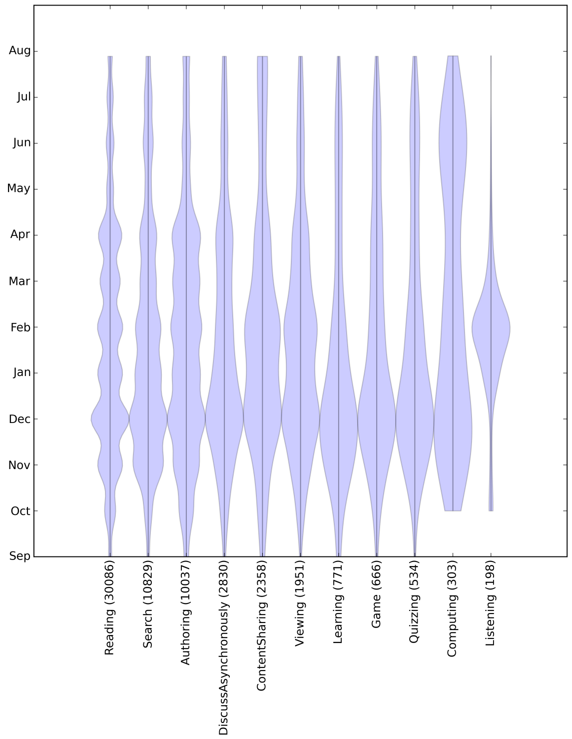

Figure 2: Tracking the intensity of activities for year 2012.

We have chosen this example to demonstrate the usefulness of semantic approach in a very simple case where a vast of e.g. usability and improvement input can be generated with a simple query and a visualization interface. Demonstration like this reveals in a very efficient manner which potentials are hidden in appliance of Semantic Web for learning analytics.

5 CONCLUSIONS AND FUTURE WORK

The overview over distribution of activities can reflect the overall interest of the learners within PLE. It can be concluded that in case of our PLE users are more consumers that contributers. Visualisation of statistics can help to improve the PLE usability in general. Activities such as e.g. ”Quizzing” and ”Listening” (from some learning object widgets) are not quite popular. Corresponding widgets that support those activities must be revised regarding usability. The statistics visualisation help us to gain deep insight into the behaviour of a single user in a certain period of time. In this simple case we demonstrated that using semantic technologies enables the extensibility of learning analytics. Our approach generates uniform interfaces for information exchange, enables flexibility for visual evaluation, and also includes the scalability regarding the enrichment of learning analytics data, since it is tolerable because of the RDF to the schema changes. Our future efforts are aiming the improvement of semantic structure data layer in order to reflect as many aspects as possible. We also want to review our widget store regarding the generated results in order to decide which widgets will further provided in our PLE and which of them need to be re-factored.

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High- vs. Low-quality Video Lectures
Don't Worry, Just Put them Online!

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Keywords: Video Lectures, Video Quality, Real-time Annotations, Crowd Sourcing, Teaching.

Abstract: This position paper claims that a major obstacle of offering video lectures for public universities appears to be the fact that they intend to compete with prestigious private universities regarding quality of the videos and complexity of the installed platform without being able to provide the additional resources required to do so. We argue that in other areas of teaching this issue has been acknowledged for a long time, and lacking resources are usually compensated for by primarily two means: individually offering provisory course material (manuscripts), and active participation of the student body in administering those. Based on this, a simple system is proposed that mostly draws on existing platforms and tools, and refrains from extensive video editing prior to publishing. We discuss technical and non-technical requirements and possible research directions that result from establishing such low-fidelity video lectures.

1 MOTIVATION

More and more private universities provide video recordings of their courses, and some even specialize on online lectures targeting a huge audience, therefore called *massive open online courses (MOOC)*. Examples are Udacity, Coursera, edX. The format switches from 90 minute lecture recordings to short clips enriched with visualisations or augmented reality to attract a worldwide audience beyond the campus.

Public universities try to copy this approach and will thus have to compete with these offers, while at the same time frequently lacking comparable resources, e.g. time of already employed lecturers, dedicated technical staff etc. Exemplary recordings in prestigious private universities are achieved with the help of a large group of dedicated experts – the MIT Open Courseware team for example includes more than 20 people[1], while at many public German universities the basic idea appears to be that the lecturers accomplish recording, editing, and publishing themselves. Supplying additional staff is usually limited to pilot projects which are then difficult to maintain once funding ends. Of course there are exceptions, but the aforementioned statement summarizes the situation we were confronted with when we started to inquire ways to provide video recordings ourselves. Our experience motivated us to consider alternative ways to tackle this issue, which we will describe in the following.

1.1 General Rationale

The first step was to bring to mind the assets many public German universities have in this case:

- A large audience that will be attending the lectures in any case as it is required by their study regulations, i.e. the predominance of on-site learning with supplementary online material over mere online classes.
- a long tradition of providing students sometimes ill-formatted, still highly informative provisory course material, i.e. manuscripts of the basic course content, which cannot compete with published books in terms of layout, but are at least as valuable with regard to content, partly due to the fact that they do not have to consider copyright issues to the same extent as an 'official' publication. Unlike in universities with high tuition fees, students expect much less professionally edited material as long as it is free or inexpensive, e.g. the master copy template residing in a library for duplication. Concomitant with that, there is

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[1] http://ocw.mit.edu/about/ocw-team

usually no centralized supervision of these manuscripts, but they are rather issued single-handedly by the lecturer.

- A mentality of active participation in the courseware preparation process among the student body, manifested in student associations (in German: 'Fachschaft'), and less the expectation of being treated as paying educational customers. It is common that these student associations offer access to self-written summaries of textbooks or exams, usually under the premise that the borrower contributes to the available corpus e.g. by writing examination minutes him/herself.

Web 2.0 communities also rely to a large extent on user-generated content. Instead of having a centralized professional editorial team, quality control is usually achieved by letting other users rate and comment the contributions, which appears to work stunningly well (Giles, 2005). A key aspect is that user involvement in the preparation of the material is quite high, which might be desirable also for the preparation of course material.

Combining these two approaches, offering educational 'raw material', e.g. mostly un-edited film footage via existing platforms like YouTube plus a couple of low-fidelity tools to annotate and extend this material might be a feasible and perhaps even desirable way to proceed for public universities with too little resources for preparing online material with high technical quality.

In the following, we will first describe a couple of such desired functionalities and outline their possible implementation to provide the reader with a more specific idea of what we have in mind, and also make clear where it extends previous similar proposals, e.g. Copley (2007). Subsequently, we will discuss non-technical requirements which will also clarify what makes us favour such a system, and mention research questions that might arise. Finally we will summarize the idea and our motivation in the conclusion.

2 EXEMPLARY SYSTEM

A combination of a couple of basic functionalities that are in part already available on popular web sites might suffice to allow for simple processing of lecture recordings. By processing we do not refer to video-editing as it is done with software like Adobe Premiere®, Camtasia® and the like, but the attempt to enrich the content of a lecture recording in order to facilitate understanding of it. In particular, these functionalities might be:

- A simple way to make videos available online for a larger audience, i.e. upload them somewhere.
- The possibility to add text comments including links to slides or other web documents at certain points of time in the video. We will call these *annotations*, and as far as they are done subsequent to the lecture, *subsequent annotations*.
- A listing of these annotations that can serve as a rough table of content or index for the video.
- The possibility to give simple ratings via a 5-star or thumbs up/down scale of added comments to indicate their usefulness
- A way to perform annotations during the lecture, e.g. to mark important or less understood parts. We will call this *real-time annotations*.

Most of these functionalities are included in professional video editing software, however, next to their price, they also require considerable training and a deeper understanding of the underlying data organization in terms of projects, audio- vs. video track, codecs, and so on. Similarly, the most prominent open-source platform to manage audio- and video lectures, *Opencast Matterhorn*, at least requires the setup of a server prior to working with it, a task that is envisaged for a dedicated campus administrator[2]. Evidently, the complexity of these programs is due to the fact that editing and publishing videos on a professional level is complex. We would like to keep all this to a minimum as it might scare off the user. To specify our proposal, a possible implementation is drafted below.

2.1 Possible Realization

For the case of simplicity, we will restrict this description to the most popular web site to publish videos, YouTube. So let's assume a simple camcorder recording of a lecture has been uploaded to this platform. The first task would be to add simple comments to certain moments in the video once it is recorded, and to make these annotations available in a way that they can be searched and serve as a simple table of contents.

2.1.1 Subsequent Annotations

YouTube already offers the possibility to add com-

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[2] http://opencast.org/matterhorn/feature-tour

ments in the video that then appear at the defined point of time inside the video once the video is played back. However, for using them as an index, it would be desirable to have access to them as a permanent text outside of the video, which also persists once the video has stopped playing. Apparently, the added notes are stored as an XML file by YouTube that can be downloaded and added to other clips[3]. In a similar way, this XML-file could be parsed and the notes including their time stamp (with regards to video clip time) extracted as text.

2.1.2 Index / TOC

The aforementioned XML comments are then used on a new web page with the video embedded, where all available annotations from the XML-file are listed in the order of their appearance in the video, desirably with the possibility to jump to the moment in the video by clicking on the corresponding time stamp. To illustrate the layout, we refer to the appearance of comments on SoundCloud[4] (see Figure 1), a popular web site to listen to uploaded music, predominately DJ sets. The search function of the web browser allows finding keywords in the comments.

2.1.3 Review

It is likely that, if done anonymously, not all annotations made by users are on the same level of appropriateness. Therefore, a simple rating system would be helpful to indicate valuable annotations. These systems are widely available as open source software (e.g. MooTools MooStarRating[5], for a discussion of various rating interfaces see (Nobarany et al., 2012), and comments with low rating can later be filtered out or deleted at all.

2.1.4 Real-time Annotations

So far, the described elements were all adopted from other sites that present user-generated content. However, one big difference to these sites is that for lecture recordings a large group of later users were already present during the time of recording. Thus it might be useful to offer them a way to start annotating in real time, i.e. while sitting in the lecture to facilitate *blended learning*, the desired combination of face-to-face and electronic lectures (Wieling & Hofman, 2010). Here, our proposal is a simple app that synchronizes with the first slide via a QR code (containing the title of the lecture or the later video file name) and then offers a GUI to immediately mark critical moments and stores them in the same XML format as the subsequent annotations so that they can later be loaded together with the actual video file. As annotation should not distract too much from attending, few, easy-to-reach functionalities would be desired (Schleicher, Sahami, Rohs, Kratz, & Schmidt, 2011). An exemplary GUI is depicted in figure 2.

The available tags or markers are limited to four types, each represented with an icon: indicating moments where the listener did not completely understand what was explained, moments that appeared important to listener or included a good example, and finally moments where the lecturer pointed out that the current statement might be relevant for the exam. This one-click-tagging might reduce cognitive overload during the lecture as it reduces the need to write down extensive notes and already facilitate later processing of the lecture recording (Mayer & Moreno, 2003).

The individual real-time annotations can be uploaded to the joint web page serving as a starting point for subsequent review by the individual student, while at the same time serving as non-personalized clusters of short tags to see where other students struggled or noted important points. A similar idea is pursued by *myTU*[6], an app for the Technical University Bergakademie Freiberg, however, their emphasis is on providing real-time feedback to lecturer in order to slow down the pace, not on subsequent review.

We are aware that several aspects of the proposed system are not completely specified on a technical level, and others may be disputable. For example the advantage of just having one common, anonymized set of annotations online and thus needing no additional user management for administrating sets of comments comes with the disadvantage that some users may not want to share their personal annotations, or cannot be contacted individually. Here, modifications are easily conceivable. The main purpose of the above given outline is to provide the reader with an idea of the system we have in mind when we now describe the non-technical requirements we see for it to work.

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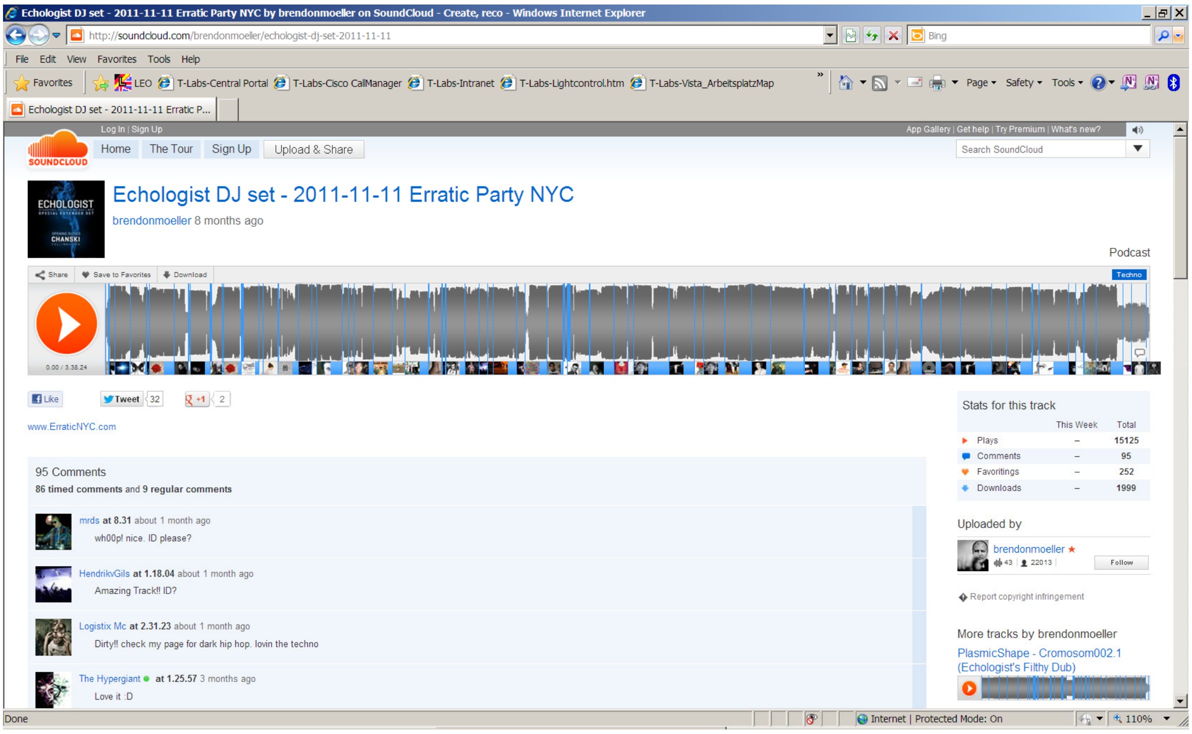
[3] http://stefansundin.com/stuff/youtube/youtube-copy-annotations.html

[4] http://www.soundcloud.com

[5] http://mootools.net/forge/p/moostarrating

[6] http://mytu.tu-freiberg.de



Echologist DJ set - 2011-11-11 Erratic Party NYC

brendonmoeller 8 months ago

www.ErraticNYC.com

95 Comments

86 timed comments and **9 regular comments**

mrds **at 8.31** about 1 month ago

wh00p! nice. ID please?

HendrikvGils **at 1.18.04** about 1 month ago

Amazing Track!! ID?

Logistix Mc **at 2.31.23** about 1 month ago

Dirty!! check my page for dark hip hop. lovin the techno

The Hypergiant ● **at 1.25.57** 3 months ago

Love it :D

Stats for this track

	This Week	Total
Plays	–	15125
Comments	–	95
Favoritings	–	252
Downloads	–	1999

Uploaded by

brendonmoeller ★ 43 | 22013 |

Report copyright infringement

More tracks by brendonmoeller

PlasmicShape - Cromosom002.1 (Echologist's Filthy Dub)

Figure 1: Layout of SoundCloud, where user comments to an audio track are listed below including the time in the track they refer to ('ID' in the comments refers to 'track ID', i.e. the specific title of the piece of music playing at that time).

Figure 2: Exemplary GUI of an app that allows for basic annotations during the lecture, containing only four types of labels/tags. Lecture time and title is given in the header of the GUI.

3 NON-TECHNICAL REQUIREMENTS

There are certain non-technical requirements to establish a comparable system, the first surely being a change of mind to move away from offering polished videos under centralized supervision, and rather go for uncoordinated low-fidelity versions, as it is the case with written material: if professionally edited video material corresponds to published textbooks, the proposal made here is to go for the video equivalent of manuscripts. As pointed out above, we did not include any video editing prior to publishing it online, because we have the impression that this constitutes a major obstacle to most lecturers interested in offering video material.

The time lecturers save editing the footage can be invested to supervise the correctness of the subsequent annotations addressing the content of the lectures, their actual area of expertise, rather than urging them to become semi-professional video editors. There are various examples of amateurish recorded lectures online (e.g. YouTube), which still convey valuable information to the viewer.

The second major obstacle we notice is a general uncertainty regarding legal aspects of offering recordings that may include pictures or other copyrighted material. This uncertainty may differ between countries (c.f. Deimann & Bastiaens, 2010) for a discussion for German institutions), as copyright laws may include a *fair use*[7] doctrine like in the US. Of course, publishing lectures as proposed here requires a certain ambiguity tolerance to reside in a legal grey zone, but we are not aware that this discussion was that prevalent for the master template of a manuscript residing in the library for every student to make a copy of it. These scripts certainly contained copyright-protected material. Here, apparently no one cared, probably because the library was not that easily accessible as content in the internet. Offering the videos only within the intranet of a university or their online learning management system (e.g. Moodle[8]) might be a compromise to establish similar conditions for digital material. However, we rather think the main reason for this previous indifference was the implicit agreement amongst all involved parties that the provisory copy cannot compete with the high-quality original. In a similar vein, the sensitivity towards copyright issues might be attenuated in the right holder if the video depicting protected items is of obviously lower quality than the officially published version, and not a lossless copy. Our intention is not to dry out commercially produced and distributed lecture material, but to complement it.

The availability of manuscripts did not keep authors off from publishing textbooks, in some cases the previously published script was offered as a beta version of the actual book. The ratings collected via 'informal' videos may help to decide which lecture should be edited and released, then in agreement with the publishers whose material is involved.

The third requirement is the willingness to switch from complete control over all content including annotations to 'moderated' control by students. In our opinion, this is the least difficult part because considering student-generated material to complement teaching is quite common at our universities, and the experiences have been clearly positive (e.g. 'informal' solutions published by a student being declared the 'official' sample solutions later on as experienced by one of the authors). To establish low-fidelity online courses as additional material, it might be necessary to provide student organizations with a couple of annotated lecture videos as some kind of initial seed. Shifting processing partly to students will encourage active learning instead of passive consumption of information, which increases both, learning outcome as well as satisfaction (Zhang, Zhou, Briggs, & Nunamaker, 2006).

The internal discussion of the approach revealed several research questions that arise from using low-fidelity video material for educational purposes.

3.1 Open Questions & Research Directions

The main questions are whether such low-fidelity videos will first be accepted by the students and lecturers, and to what extend it will actually support the learning process.

We think that using platforms and interaction concepts instructors and students are familiar with from their daily internet browsing (watching YouTube videos, rating content, and adding comments) will be less time-consuming than getting used to completely new tools. We are aware of the impact technical quality of audiovisual material has on the recipient (Möller, 2010)(Arndt, Antons, Schleicher, Möller, & G., 2012), although the issue might not be as important as reported in (Lauer, Müller, & Trahasch, 2004) due to a general increase in available bandwidth since then. The Opencast Matterhorn app *Matterhorn 2 go*[9] for example offers searching and watching video lectures on the mobile phone. Nevertheless, the lower quality as compared to MOOC clips will of course be obvious, and may in some cases even lead to ambiguous or non-understandable sections. The euphemistic reply would be that this emphasizes the 'authentic' character of the material like jittery mobile phone clips presented in news shows, where the unedited nature of the clips almost increases their credibility.

However, this may be too optimistic, so let's assume that the quality impairments simply prevent understanding of certain sections. Here, a look in the other available course material may be necessary, probably based on the recommendations of fellow students. The fact that processing a lecture cannot be achieved without supplementary material might also help to attenuate one objection we repeatedly heard from lecturers, namely the worry that offering online versions will discourage students to attend the classroom. The more obvious it is that working with the video material already starts in the lecture (by anno-

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[7] http://www.copyright.gov/fls/fl102.html

[8] https://moodle.org/

[9] http://vm193.rz.uni-osnabrueck.de/matterhorn2go

tating it in real time) and that attending it will have benefits in terms of acoustic and visual quality (as compared to the low-fidelity video), the less an attitude of 'I can attend it later/at home' will arise.

4 SUMMARY & CONCLUSIONS

In this position paper, we outlined a simple way to offer video recording of lectures with low technical quality to students and enable them to use this as supplementary learning material. Unlike most available systems, the approach aims at utilizing existing platforms and interaction paradigms as much as possible, namely the possibility to watch videos online via e.g. YouTube, add comments, and rate those comments. Instead of editing the videos extensively prior to uploading, the idea is that the main focus should be on content-related annotating, which can to a large extend be achieved by the students. To facilitate this, they should be enabled to already start with annotating while attending the lecture.

Shortcomings due to limited annotation functionalities or arguably low technical quality of the video footage are acknowledged and accounted for by explicitly stating that the videos are just an additional teaching supplement without the intention to replace other material or even lecture attendance.

This proposal is based on our experience that the attempt to compete with platforms that offer professionally produced video lectures might fail without providing substantial additional resources regarding technical as well as legal expertise. At the same time, the imbalance in resources has been dealt with for a long time in other areas of teaching at public universities both by students and lecturers alike, who usually compensate for it by individually providing material with low technical quality and increased participation of the student body. We tried to show how the same principle might be applied to video lectures. The intention is to encourage all involved parties, lecturers and students as well as experts on e-learning to further develop this idea.

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Use of Multi-touch Gestures for Capturing Solution Steps in Arithmetic Word Problems

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Keywords: Mathematics, Problem Solving, Multi-touch Interfaces, e-Assessments, e-Learning Tools.

Abstract: Multi-touch interfaces are becoming popular with tablet PCs and other multi-touch surfaces increasingly used in classrooms. Several studies have focused on the development of learning and collaboration potentials of these tools. However, assessment and feedback processes are yet to leverage on the new technologies to capture problem solving steps and strategies. This paper describes a computer aided assessment prototype tool that uses an innovative approach of multi-touch gestures to capture solution steps and strategies. It presents a preliminary effort to investigate the capturing of solution steps involving a two-step arithmetic word problem using the approach. The results suggest that it is possible to perform two step arithmetic work with multi-touch gestures and simultaneously capture solution processes. The steps captured provided detailed information on the students' work which was used to study possible strategies adopted in solving the problems. This research suggests some practical implications for development of automated feedback and assessment systems and could serve as a base for future studies on effective strategies in arithmetic problem solving.

1 INTRODUCTION

Assessment is central to the learning experience (JISC, 2010). In recent years, there has been an increasing interest in using technology to enhance assessment and feedback processes. New technologies are revolutionizing work, play and study. The technologies suggest new opportunities to include touch and physical movement, which can benefit learning, in contrast to the less direct, somewhat passive mode of interaction suggested by a mouse and keyboard. Current research reveals that the ownerships of technologies such as tablets and hand held devices among learners are likely to be widespread (Heinrich, 2011). Other studies have shown that hand held tablet devices and smart phones have significant and very positive impact on learning and motivation of students; leading to increased capacities to research, communication and collaboration(Banister, 2010; Gasparini, 2012; Heinrich, 2011).

Despite the digitally enhanced landscape in which learning now takes place, assessment and feedback practices are yet to fully leverage on the technology to provide innovative solutions to identified problems. A criticism of some implementations of computer aided assessment is that the design sometimes limits creative problem solving. The most common question type used in such systems tends to be based on convergent, selected responses. Some practitioners have argued that the practice has little pedagogic value beyond testing surface learning (Hommel et al. 2011).In solving a two-step arithmetic word problem for instance, selecting a single best answer among other options for grading presents some difficulties. First, only the final answer is compared against the correct answer, making it difficult to obtain intermediate results or award partial marks as possible with paper based assessments. Second, solution paths or strategies are not explicit. The limited information on the steps and strategies makes it difficult to give detailed and personalized feedback on a student's work.

This paper discusses a new and innovative approach to computer-aided assessment that uses multi-touch gestures to capture solution steps and strategies. A small pilot study was conducted using the prototype tool to obtain and examine solution steps of a two-step arithmetic word problem.

2 APPROACH

Effectively capturing solution steps and strategies requires a tool that is educationally justified. It must follow sound pedagogic principles and contribute to learning, and it should provide an environment that freely allows creative problem solving without increasing cognitive load. It should be possible to capture solution steps without disturbing the user.

Multi-touch interaction is a new technique that allows users to interact naturally with digital objects in a physical way, and could help to address the requirements. The pedagogic advantages of using gestures have been studied (Drews & Hansen, 2007; Goldin-Meadow & Beilock, 2010; Segal, 2011) .The studies show that multi-touch technologies can benefit cognition and learning (Barsalou, Niedenthal, Barbey, & Ruppert, 2003), augment working memory (Goldin-Meadow, 2009) . Also, the mode of interaction allows for bimanual input which increase the parallelism of manipulations and reduce the time of task switching(Jiao, Deng, & Wang, 2010).

Consider a two-stage arithmetic word problem that involves three numbers, say 2+5+8. Students are typically taught to solve the problems in two separate stages i.e. by adding numbers in pairs. Fischbein et al. (1985) argued that intuitive models associate addition with *putting together*. The first stage adds 2 and 5; using bimanual multi-touch interaction makes it possible to simultaneously work on the two numbers. Although it is possible to use single touch to interact with the numbers one at a time, it is rather cumbersome, less intuitive and requires too many steps. The first step produces an intermediate result which is used in the next stage. It is interesting to note the first step has six possible combinations (2+5, 2+8, 5+2, 5+8, 8+2, and 8+5) and the second step similarly has six possible correct combinations of the number pairs (7+8, 10+5, 7+8, 13+2, 5+10, and 2+13). The diversity of solution paths increases if the other arithmetic operators (-, x, ÷) are required to solve the problems. Capturing the particular number choices made by the student during the interactions should provide detailed feedback on the steps the student has taken to solve the problem. This feedback provides an opportunity to examine the strategies adopted in tackling the problem.

To capture the solution steps without increasing the cognitive load,(Chandler & Sweller, 1991) the tool needs to implement a smooth user interface which allows students to enter the solutions freely and easily. The interface should present the question and the solution work areas. For this study, the problem text and the solution workspaces are placed together on the same page. This aids the student memory of the problem context and requirements. This arrangement is known to have pedagogical value and has been used in different studies (Suraweera & Mitrovic 2002; Stone et al. 2009; Batmaz et al. 2009) .Also, it allows the student to focus fully and continuously on the task at hand without having to flip back and forth between pages. Another advantage is that it facilitates user interactions between the workspaces with minimal disruption. The solution space will not provide any toolbox, options or hints and should allow free form entry design space.

The method of capturing steps and strategies is comparable in complexity to that used for design rationale capture – an area widely studied. Design rationale has been defined as the reasoning and argument that leads to the final decision of how the design intent is achieved (Sims, 1997). A variety of methods have been used to capture the rationale, each has its advantage and disadvantages. A method known as reconstruction method captures the rationale after the design. This approach does not interrupt the flow of the design effort but does not provide accurate or complete rationale capture, because people usually do not accurately explain how or why they do things. Another method referred to in literature as apprentice system Sims 1997), requires asking the designer questions as the design action is carried out. This method is time consuming and frequently interrupts the design effort. A third approach captures the rationale implicitly. This approach is used for this work as it does not obstruct the process and has minimal time overheads.

2.1 The Multi-touch Arithmetic Tool

The prototype tool developed on the iPad is called the multi-touch arithmetic tool (MAT). The tool supports questions of different complexities including all arithmetic operations and provides and captures solution steps. Figure 1 presents a description of the tool. It has word problem pane on which questions are presented to the student and the solution pane.

The word problem text section presents problems with numeric values that can be dragged to the solution area by using simple touch and drag gestures with one or both hands. The numbers dragged on the solution pane are referenced to the numbers on the problem text using techniques developed by Batmaz and Hinde (2006). The bottom

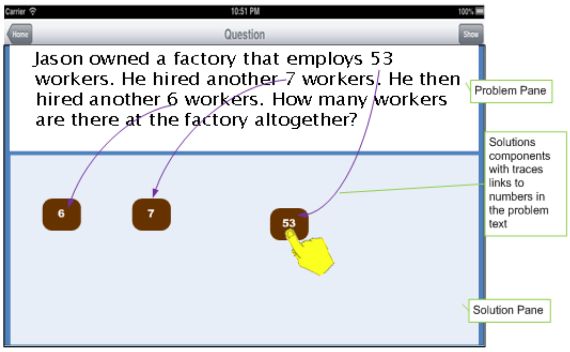
Jason owned a factory that employs 53 workers. He hired another 7 workers. He then hired another 6 workers. How many workers are there at the factory altogether?

Figure 1: The Multi-touch Arithmetic tool.

pane is the working pane where the student solves the problem From the problem pane, the student chooses the numeric values and drags them to the solution as illustrated in Figure 1. Two or more numbers can be moved this way. When this is done the student simultaneously selects any pair of numbers by touch holding them for about 3 seconds (so called long press gesture), this action brings up a pad containing arithmetic operators from which the user selects an appropriate operator to solve the problem (shown in Figure 2).

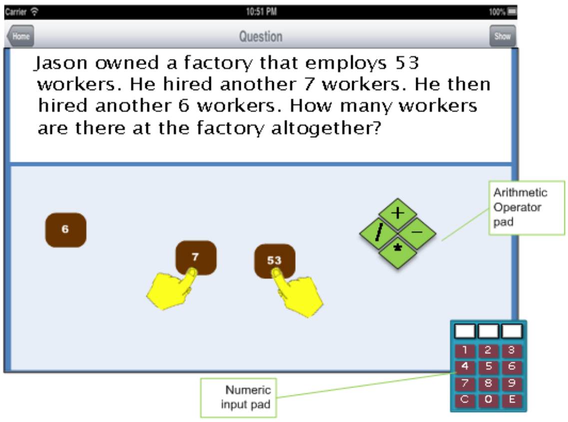
Jason owned a factory that employs 53 workers. He hired another 7 workers. He then hired another 6 workers. How many workers are there at the factory altogether?

Figure 2: Performing arithmetic operation with two hands.

For example Figure 2 shows a question involving the addition of employees, the problem has three numbers in it which can be carried to the solution pane. The user selects the two numbers to apply an arithmetic operator by dragging the numbers together. Note users can only apply an arithmetic operator on the number pair they choose. This gives the opportunity to capture the two numbers the student is working on. A successful selection of an arithmetic operator results in a display of a numeric key pad, through which a calculated result is inputed.

The result of this intermediate step is fed to the next stage of the solution process by the same drag or pan gesture, whiles the touch and hold gesture is used as above for the arithmetic operation (Figure 3).

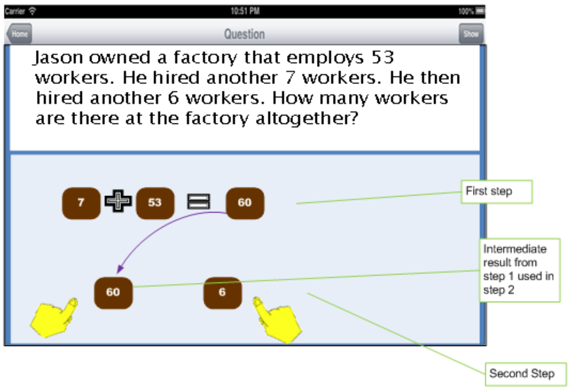
Jason owned a factory that employs 53 workers. He hired another 7 workers. He then hired another 6 workers. How many workers are there at the factory altogether?

Figure 3: Using intermediate results as inputs to other steps.

The same process is repeated for all numbers and intermediate results in the problem text until a final solution is arrived at. Figure 4 shows the feedback of the solution process.

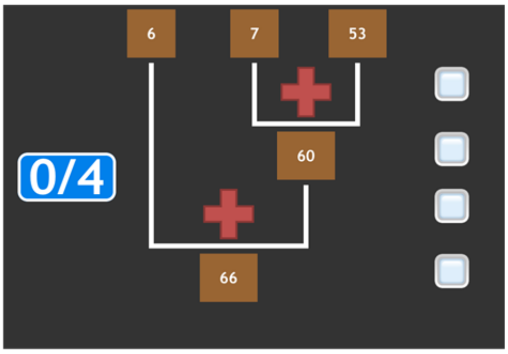

Figure 4: Feedback on solution steps.

The figure indicates that the first step used for solving the problem is 7 +53. The result of this step is 60 – an intermediate result which was used in the second step. The second step used the result with the third number i.e. 60 + 6 to obtain a final result of 66. The individual steps and intermediate results can be assigned marks and graded.

3 PILOT STUDY

The study described in this section was set out to determine if students can successfully solve the arithmetic problems using the prototype tool.

Participants were Loughborough University students. It is assumed that they will not have difficulty with arithmetic tasks but are unfamiliar with the multi-touch approach. Although the participants are university students, we believe the findings may be relevant to younger learners as well. Seventeen students were enrolled for the study. An introduction session was given to each participant on sample question to intimate them on how to use the tool to solve problems. After this, they were asked to solve three word problems using the techniques demonstrated. The word problems used are shown in Table 1.

Table 1: Two Step Arithmetic Word Problems.

Problem	Strategy
Q1.William had 7 bottles of wine. His father gave him 41 more bottles of wine. His mother gave him 9 more bottles of wine. How many bottles of wine did William have altogether?	start with 41 then add 9 then add 7
Q2. Sara has 8 sugar donuts. She also has 5 plain donuts and 32 jam donuts. How many donuts does Sara have altogether?	start with 32 then add 8 then add 5
Q3. Jason owned a factory that employs 53 workers. He hired another 7 workers. He then hired another 6 workers. How many workers are there at the factory altogether?	start with 53 then add 7 then add 6

It was hypothesized that two main strategies would be detected from the output results, namely the *place-value strategy* in which the student starts by selecting two numbers that sum to a multiple of 10 in order to reduce computational burden (e.g. 41 + 9 would be the first number bond in the example given above), and the '*as presented' strategy* – where the order numbers appear in the question is followed from left to right. We also anticipated that some students would select numbers arbitrarily.

The numbers were chosen to support the use of the place-value strategy by students such that in each problem there is a large (two-digit) number, and a corresponding small (single-digit) number that sum to a multiple of 10. In each problem the two-digit number is presented in a different position: 2nd in question 1; 3rd in question 2; 1st in question 3. The particular values were selected so that adding the single digit numbers was not too easy, i.e. every single digit addition requires a carry over. The large numbers were selected such that each question is most easily answered by starting with the large number, and then one of the smaller numbers (i.e. the place-value strategy). Question 3 presents the numbers in strategic order. This is a control question to help us work out if any participants consistently either (i) just chose numbers from left to right or (ii) just choose numbers arbitrarily.

It can be hypothesized that those with a conceptual grasp of addition will consistently use the place-value strategy described above. Those who do not have a conceptual grasp of addition will go left to right, select numbers arbitrarily or only make partial use of the place-value strategy.

4 RESULTS AND DISCUSSION

The present study was designed to determine the suitability of the multi-touch approach in solving arithmetic word problems without constraining problem solvers. The solution steps were captured for feedback and assessment purposes. The results obtained from the students showed each step to have five to six different solution paths.

To assess the usability of the multi-touch approach, the participants on completing the tasks were asked to respond on their being able to solve the problems. The overall response to this question was very positive, all the participants expressed that they were able to successfully carry out the tasks. Analysis of the detailed results generated on the tool showed that 98% of the participants had correct answers. Only one participant approached a question using subtraction rather than addition, and this may be due to his lack of proper understanding of the question. To assess how comfortable the participants were with the solution process, they were asked to response to a Likert-type question on a six point scale on how easy it was to use the tool. Over half (53%), responded that the found the tool moderately easy to use, 35% found it very easy while the others (15%) reported using it was sort of easy. While the study did not set out to test arithmetic ability, the results suggest that the tool did not prevent the students from solving the questions and inputting answers thought to be correct.

Turning now to the question on strategies, the steps and order in which the participants answered the problems were all captured. An analysis of the responses showed different patterns or strategies to solving the problems can be detected. It was hypothesized that two major strategies can be implied from the order the numbers were paired, (e.g. here we do not discriminate between participants paired 41 + 7 from those who paired 7 + 41). The strategies output from the tool are summarized in Table 2. Across all participants just over half of the questions were solved by starting with a place-value addition that resulted in a round number (e.g. 53 + 7). However the use of strategies varied across the three questions. Fewer than half of the participants used the place-value strategy for questions 1 and 2 whereas most participants appeared to use it for question 3. These between-question differences were significant, $\chi^2(2, N = 17) = 6.75$, $p = .034$, suggesting participants were more disposed to using the place-value strategy for question 3 than they were for questions 1 and 2.

Table 2: Strategies used by the participants to solve the questions.

STRATEGY	Q1	Q2	Q3	TOTALS
place-value	6	7	13	26
other	11	10	4	25

This result is consistent with our hypothesis that some participants would use the place-value strategy, and others would use the ‘as presented’ strategy. For questions 1 and 2 those using the place-value strategy could be discriminated from those using the ‘as presented’ strategy. However question 3 was deliberately designed such that the place-value and ‘as presented’ strategies were the same (53 then 7 then 6). Therefore the reason most participants appeared to use the same strategy in question 3 is that the place-value and ‘as presented’ strategies were counted together.

The results suggest that while some participants were disposed to using the place-value strategy, overall most participants used the ‘as presented’ strategy on most questions. In light of this finding we scrutinized the data for evidence of our hypothesized distinct groupings of participants. The small sample size (17) and small number of questions (3) meant this was merely a descriptive exercise and no generalizable conclusions can be drawn. Nevertheless, we anticipated a ‘larger’ group who consistently answered all three questions by adding the numbers as presented, and a ‘smaller’ group who consistently used the place-value strategy. To a limited extent this is what we found: 3 of the 17 participants consistently added the numbers as presented, whereas only 1 consistently used the place-value strategy. Although these numbers are small they are encouraging given the size of the data set, and demonstrate how in principle the tool might enable the detection of distinct arithmetic strategies.

5 CONCLUSIONS

This paper has investigated the approach of using multi-touch gestures to solve two step arithmetic questions. The pilot study set out to capture solution steps as the problems were solved and obtain feedback from the participants on usefulness of the approach. The results showed that students were able to freely solve arithmetic problems without being constrained to limited options or solution paths. The tool demonstrates that detailed information on solution steps can be captured without obstructing a creative problem solving process. Analysis of captured data suggests that solution strategies can be detected.

However, the findings are subject to at least two limitations. First, the study used a convenience sample size – which was sufficient for descriptive purposes, but may not suffice to reach generalizable conclusions on the strategies. Second, university students were the participants used to acquire feedback on the approach and to generate multiple solution paths. While the findings are useful and applicable to students, they may not be transferable to children.

Nevertheless, the study suggests several courses of action: Further experimental investigations on a larger population involving primary school children are required to determine if a relationship exists between strategies and successful problem solving. The diversity of solution paths is likely to increase the marking and feedback workloads of teachers if done manually, a next step will be the study and development of automated or semi-automated marking techniques.

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POSTERS

Facilitating Learning and Knowledge Transfer through Mentoring

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Keywords: Mentoring, Social Media, Web-based Platforms, Communities.

Abstract: Mentoring is a human resources development process supporting learning and knowledge transfer. Social media and Web services can be used for learning, communication with mentors and monitoring bringing also other advantages. In this paper formal and informal mentoring aspects and the use of IT in mentoring particularly social media and Web support will be shortly presented. Examples of projects where besides knowledge transfer, formal, informal learning also learning in a Web-based community is used are outlined.

1 INTRODUCTION

Mentoring is a human resources development process supporting learning and knowledge transfer – KT (Argote and Ingram, 2000). It can be organized to address aspects like knowledge gaps and shortage skills (Hamburg and Marian, 2012). Mentoring, is commonly used to describe a KT and learning process in which an existing staff member or an external one guides new comers or less-experienced people in a task and helps to develop professional skills, attitudes and competencies (Johnson and Ridley, 2008; Edelkraut and Graf, 2011). Mentoring is a complex process involving not just guidance and suggestion, but also the development of autonomous skills, judgments, personal and professional master ship, expertise, trust and self-confidence over the time (Richert, 2006; Breipohl and Hamburg, 2011). The nature of mentoring is "friendly", "collegially".

Relationships within mentoring processes are often divided in informal and formal ones. In the next part we will give some characteristics as well as advantages and disadvantages of these two types.

Due to mentoring effectiveness for developing more productive staff, many organisations are interested to support it. Some examples of professional contexts in which mentoring can take place are induction programmes to maximise the graduate´s learning, continuous professional development supporting professionals to develop new skills and gain additional experience and knowledge, career development, outplacement helping individuals (particularly some with special needs) to integrate into work or to make transitions in new forms of employment, changing management or at implementing a learning organisation.

Informal learning accounts for over 75% of the individuals and companies learning processes, it is necessary to support the use of this form of learning more efficiently also in the mentoring, counselling and coaching and to combine it with new IT services. Strategies using intensively informal learning, e-Learning, mentoring and new IT media, embedded into business and work processes in companies, responding not only to requirements of work/career but also to employees interests and supporting collaboration, knowledge sharing and performance should be developed.

According to organizations using mentoring, social media can be used for communication with mentors and monitoring bringing also other advantages. The use of social media support social learning; forums, blogs, virtual market places, extend face-to-face traditional mentoring allowing mentoring to take place over distance and in different time periods. This approach supports also not only informal but also formal mentoring, more accepted by the organizations because they see direct benefits making also possible that more mentees are mentored.

In this paper formal and informal mentoring aspects and the use of IT in mentoring particularly social media and Web support (O´Reilly, 2005) will be shortly presented

Example of projects where besides KT, formal and informal learning also learning in a Web-based community (Wenger et al., 2002) is used, are outlined.

2 FORMS OF MENTORING

The range of mentoring relationships is a continuum going from informal mentoring to formal, highly structured and planned mentoring.

Informal mentoring is created spontaneously or is initiated by special interest i.e. when the mentee could be a potential employee. An informal mentoring relation can be required by a mentee who approaches a mentor for his/her intentions.

Some characteristics:

- Goals of the relationship are not completely specified
- Outcomes could not be measured in totality
- The process of KT cannot be explicitly described and it is based on the ability and willing for this process
- Access is limited and could be exclusive
- Mentors and mentees are often selected on the basis of personal chemistry that means an initial connection or attraction between
- Mentoring lasts a long time
- The organization benefit indirectly, as the focus is exclusively on the mentee.

Some advantages are a relationship of trust and respect between the partners, high degree of compatibility and cooperation and flexibility of the relation. This kind of relationship has a risk of ambiguity and tension when it becomes too intensive and there are rare possibility to be applied to groups. The most used form of learning in this context is an informal one. Social networks support this type of mentoring.

Formal mentoring is often facilitated and supported by the organisation which makes also tools available to participants for an efficient process.

Some characteristics are:

- Goals are established from the beginning by the organization, men-tors and mentees
- Outcomes are measured
- Knowledge which has to be transferred is known at the beginning
- Access is open to all who meet the criteria established by the organization for the corresponding mentoring program
- Mentors and mentees are paired based on compatibility
- Organisation and employees can benefit directly.

Aspects as the difficulties by paring with the risk of poor one and less flexibility of relationships between mentor and mentees and of the mentoring process are disadvantages. Formal mentoring relationships are more suitable for using e-Learning and Web-based systems can support formal mentoring. The type of appropriate mentoring for an organisation depends on its business and qualification needs, on the needs of mentees. The success will depend on whether the parties involved in the mentoring process have the skills required and if the context of the organisation is supportive.

3 SOCIAL LEARNING ENVIRONMENTS AND WEB-BASED SUPPORTED MENTORING

IT platforms supporting social networks can be considered as tools for KT, ways to store organisation knowledge and spaces where employees share knowledge and guide colleagues. One disadvantage of existing social learning platforms is that they do not support a synchronous communication. Web facilities as moderated forums, wikis, and blogs improve the mentoring process in this context. Web-based supported mentoring in networks and a platform by using social media has benefits:

- Provision of a 24 hour access of saved knowledge, for training material and communication
- Accessible anywhere with internet availability
- Provision of a platform even if face-to-face communication is not possible
- Learning assessment and progress monitoring of the mentor/mentee relationship
- Accounting for different learning abilities of mentees
- Overcoming limitations in time or space etc. of traditional training environments
- Reducing limitations of the classroom
- Allowing the learner to work at his or her own space, speed and depth with structured support from both, the educators and the other learners.

Important aspects for a successful mentoring process are trust and the depth of relationships. Face-to-face interaction and socialization processes consolidate the relations between members and group membership. Trust is important for KT and this develops primarily through face-to-face interactions so traditional elements of monitoring/mentoring have to be affiliated (Eby and Allen, 2008). A constant presence of experienced and qualified mentors in the Web-based platform is required. The platform should support motivation and retain students in the learning process and a real mentoring and not be understood as a supervisory tool.

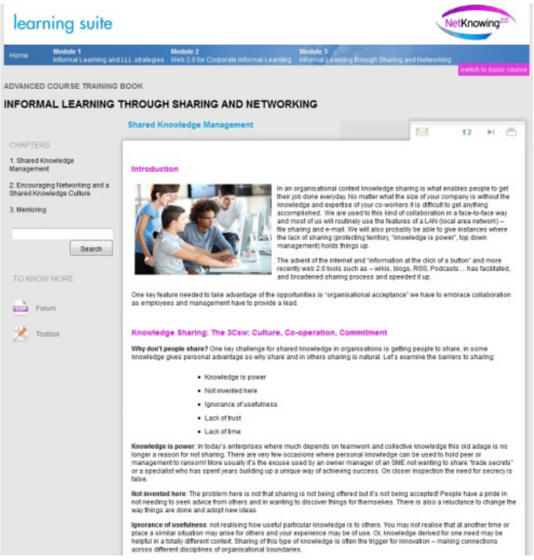
4 EXAMPLES

One European project within Leonardo da Vinci programme is Net Knowing 2.0: Web 2.0 Technologies and Net Collaborating Practices to support learning in European SMEs (www.netknowing.com). It aims to support KT in European SMEs by using informal learning, networking and mentoring and to help them to turn their daily work into a source of corporate learning.

Within the project we discussed with SMEs about introducing a mentoring system facilitating performance and KT, supporting retention and leadership development. Mentoring is less used in Germany. Within a workshop with German representatives of SMEs some tactics for implementing a mentoring program in their companies have been discussed. One possible approach is that experienced in Brandenburg. The mentors are external persons who should support the sustainable development and advancement of strategic competences of SMEs through informal and formal learning. Potential learning consultants can be trained to act as mentors. Some companies decided to try this concept and also to use company staff as mentors for 1-2 mentees with disabilities who will work for the company. In this case informal mentoring will be used and the KT will be very beneficial for the mentee in the own career but and also for the mentor. At the workshop, SMEs from Germany proposed a route map for the successful deployment of a mentoring program within the specific context of a SME environment:

- Putting the specific working environment into context.
- Researching the role played by the organisational culture or "climate" in the development, maintenance and success of the SME.
- Determining real qualification needs of the staff before starting the mentoring process.
- Determining the knowledge gaps and which of them can be minimised by a mentoring system.
- Demonstrating that a mentoring intervention has real benefits in this context and not being bureaucratic.
- Being a process based on trust, experience, supervision, formal and informal learning.
- Identifying barriers to mentoring/coaching.
- Determining issues to be incorporated within the mentoring/coaching intervention, for success.
- Qualifying coaches and mentors for different forms of working and learning.

This map is considered in the future mentoring activities in Germany. A learning suite has been developed including a training module for mentors. The module which has been required by SME representatives and other users of the learning suite has been translated in German to be used in further mentoring processes in Germany. The few mentoring activities carried out till now in Germany have been positively evaluated by companies, colleagues and mentees. More moderated forums have been required.



ADVANCED COURSE TRAINING BOOK

INFORMAL LEARNING THROUGH SHARING AND NETWORKING

Shared Knowledge Management

Introduction

In an organisational context knowledge sharing is what enables people to get their job done everyday. No matter what the size of your company is without the knowledge and expertise of your co-workers it is difficult to get anything accomplished. We are used to this kind of collaboration in a face-to-face way and most of us will routinely use the features of a LAN (local area network) – file sharing and e-mail. We will also probably be able to give instances where the lack of sharing (protecting territory, "knowledge is power", top down management) holds things up.

The advent of the internet and "information at the click of a button" and more recently web 2.0 tools such as – wikis, blogs, RSS, Podcasts… has facilitated, and broadened sharing process and speeded it up.

One key feature needed to take advantage of the opportunities is "organisational acceptance" we have to embrace collaboration as employees and management have to provide a lead.

Knowledge Sharing: The 3Csw: Culture, Co-operation, Commitment

Why don't people share? One key challenge for shared knowledge in organisations is getting people to share, in some knowledge gives personal advantage so why share and in others sharing is natural. Let's examine the barriers to sharing:

- Knowledge is power
- Not invented here
- Ignorance of usefulness
- Lack of trust
- Lack of time

Knowledge is power: In today's enterprises where much depends on teamwork and collective knowledge this old adage is no longer a reason for not sharing. There are very few occasions where personal knowledge can be used to hold peer or management to ransom! More usually it's the excuse used by an owner manager of an SME not wanting to share "trade secrets" or a specialist who has spent years building up a unique way of achieving success. On closer inspection the need for secrecy is false.

Not invented here: The problem here is not that sharing is not being offered but it's not being accepted! People have a pride in not needing to seek advice from others and in wanting to discover things for themselves. There is also a reluctance to change the way things are done and adopt new ideas.

Ignorance of usefulness: not realising how useful particular knowledge is to others. You may not realise that at another time or place a similar situation may arise for others and your experience may be of use. Or, knowledge derived for one need may be helpful in a totally different context. Sharing of this type of knowledge is often the trigger for innovation – making connections across different disciplines of organisational boundaries.

Figure 1: Learning suite.

Another project is Diversity and Mentoring Approaches to Support Active Ageing and Integration DIMENSAAI (www. dimensaai.eu) starting end 2012 and coordinated by the author. By transferring a mentoring model from former projects to Germany and other partners, the consortium wants to improve participation in training and particularly on the job qualification and employment for two target groups: seniors and people with disabilities by the use of a diversity and mentoring model focusing on the working places in the health and care sectors (having skill shortage). Activities planned are the organization of focus group discussions to identify requirements for working places suitable for these groups and needs for mentoring, the transfer, adaptation and test of a mentor training model and developing a catalogue with competencies for mentors, workshops in health/ care sector and other interested organizations for explaining diversity, tests of mentoring processes on the job in the partner countries involving seniors and/or disabled persons, social networking.

In both projects social networking of mentors, mentees and other experts is supported by an IT platform developed by using TiKi Wiki (Wikipedia, 2012). Tiki is an open source, Web-based application, offering collaboration, publishing, commerce, social networking. In Net Knowing 2.0 the platform (cop.netknowing.eu) is connected with learning suite, particularly with mentor module.

The following figure shows the social platform (www.platform.dimensaai.eu) offering also training for mentors and diversity counsellors within DIMENSAAI project.

Welcome to the social learning community of DIMENSAAI

This platform provides:

- Social networking service
- Moderated forums
- Innovative training sessions for diversity counselors and mentors
- Cooperation between project partners to develope products and training materials

To join our community you must register yourself and then login
Click here to register
Click here to login

Figure 2: DIMENSAAI platform.

5 CONCLUSIONS

In the last years nature and perception of mentoring have changed being more based on equality. Aspects that we considered till now in our projects for making mentoring a successful process i.e. to open new horizons for mentee without imposing mentor own agenda, adapt the mentoring style to mentee needs, supporting mentees to help themselves, reflect critically and known own limitations and boundaries and asking feedback from mentees.

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Bringing Tablets to Schools
Lessons Learned from High School Deployments in Germany

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Keywords: Tablets, Schools, Teaching, Interactive, Android, iPad, Multimedia, Math, Foreign Languages.

Abstract: Tablet deployments at schools are becoming more and more popular. Research on how to effectively use tablets for teaching is unfortunately mostly missing. With this paper we share our experiences from various high school deployments in Germany. During these deployments we have developed a novel learning style designed for tablet-based teaching. We have evaluated our deployments through interviews with teachers and students. A quantitative survey compares the use of tablet devices with laptop computers.

1 INTRODUCTION

Tablet computing is quickly spreading in schools around the world. Even though the device category of tablets has just been introduced a mere two years ago, we see an astonishing rate of adoption in a market, which used to be more conservative. We see a wave of enthusiasm by both teachers and students unequal to anything we have seen before as far as computing at school goes. Particularly, this excitement seems to have completely been missing from previous laptop based school projects, such as the One-Laptop-Per-Child movement (Negroponte, 2006) and other deployments.

Based on our experiences gathered from high school deployments in Germany, we want to discuss the elements of tablet computing that make a difference. We are trying to answer the following research questions: What are the strengths/weaknesses of tablets compared to e.g. laptop computers? How can tablets be successfully deployed at schools?

Above all, there is a need for teaching concepts and learning content to support teachers. Teachers have to know how best to use tablets It is certainly not enough to just handout iPads. This is why some deployments have failed or were discontinued.

In this paper, we present the results from interviews and surveys conducted in various tablet deployments at high schools in Germany. Based on these experiences, we propose a novel interactive learning style with a focus on tablet-based teaching. For our deployments, we developed learning content, which leverages both the multimedia capabilities and simplicity of use of tablet computers. The corresponding lessons were implemented using the open data format proposed in (Weible and Seemann, 2013).

Figure 1: Main screen of the developed tablet software for high school students.

2 RELATED PROJECTS

Research in the field of tablet based teaching lags obviously behind real world deployments. Schools have started to adopt tablet devices before large scale scientific evaluations could be performed. The first iPad appeared in April 2010, since then the research community has not had much time to develop, deploy and evaluate these devices. First results from pilot projects have often not yet been published or are sometimes not even scientifically evaluated. One of the first published results by Isabwe et al. (Isabwe et al., 2012b; Isabwe et al., 2012a) concentrates on math teaching and peer assessment techniques. Still unpublished efforts include an initiative for K12 math by Shocken et al. (Schocken, 2012) (creator of Nand2Tetris (Schocken et al., 2009)). A more comprehensive discussion on the use of tablets in different subjects is, to our knowledge, still missing. The research community is certainly trying to close this gap, but we are only starting to catch up.

2.1 Tablet Deployments

Tablet devices have already been widely deployed at many schools in the US and Western Europe. Often, these deployments result from the initiative of local teachers and parents. Larger deployments initiated by government organizations are much less frequent.

In the following we would like to briefly mention two examples of those deployments in Italy and Germany.

One of the larger deployments is a project in sourthern Tyrol, Italy (Farias, 2011). Several hundreds of students participate in a pilot project on tablet-based teaching. The project uses Android tablets and all school books are provided in electronic form by the respective publishers.

The first goal of the project to replace conventional textbooks has already been accomplished and both students and teachers are very satisfied with the solution. The crucial point of adapting the text book's content to tablet based teaching has not yet been tackled by the publishers so far. In most cases they just provide a PDF file of their traditional paper-based text book.

Another deployment is organized by the city of Mannheim, Germany (Klinga, 2011). This deployment of some hundred tablets is based on the popular Apple iPad. The iPads are not supposed to replace conventional text books, but e.g. to create multimedia presentations or documentations. The exact use of the tablets in the curriculum, however, depends on the individual teachers (Klinga, 2011).

Since publishers are not involved in the project, it is often not obvious for teachers to find appropriate content. While there is a certain amount of material available in English (e.g. in the iBook Store), content in other languages e.g. German is mostly missing. Many critics therefore even believe that tablet-based teaching is a temporary, short-term fashion, which will eventually fade. This again stresses the urgent need for optimized, interactive content.

2.2 Learning Content

Because of the lack of scientific and practical experience, publishers and teachers seem to be unsure how to create content for the new devices. There is no widely accepted learning concept or content available for tablet devices.

Apple has proposed a proprietary standard namely iBooks to create such content and wants to provide the technical platform. Relying on this iBook standard, however, gives Apple full control over the distribution. More over, publishers are restricted to features provided by the iBooks software. These are two of several reasons why many publishers have so far been skeptical about this platform.

Some publishers prefer the competing Android platform developed by Google. At this moment, there is, however, no established standard and little content beyond traditional books (provided as E-Book).

3 COMPUTER USAGE

Historically there have been many debates on whether to use computing devices for teaching. The more important question, however, is when and how to use those devices. Here the new form factors of computing: laptops and tablets have paved the way to a more ubiquitous use of computers in schools.

All of these form factors have certain strengths and weaknesses as far as effective learning is concerned. We will discuss these in the following two subsections. In particular, we would like to point out the reasons, why tablet devices have become so popular in such a short time.

3.1 Laptops

Even though there have been many ambitious projects, e.g. the One-Laptop-Per-Child project by Nicholas Negroponte (Negroponte, 2006), laptops have not revolutionized our way of teaching. While they are very capable devices, in fact, they are much more capable than today's tablet devices, teachers are still hesitant in the adoption.

One issue has certainly been the relatively high price for schools and students. However, the more important issues seem to be that laptops are complicated. Schools need trained system administrators to setup and maintain the devices. And also students, particularly younger students, need training to get accustomed to keyboard, mouse and a complex operating system.

3.2 Tablets

Tablet adoption is very much on the rise, even though they are often not cheaper than conventional laptops. What are the reasons for this?

According to our experiences tablets provide multiple advantages over laptops. First, tablet devices need less administration. This is, on the one hand, due to the fact, that they currently offer a more limited set of functionalities. On the other hand, the respective tablet ecosystems are tailored towards ease of use. Students do not have to be skilled with the mouse or keyboard and applications are typically stripped down to the essentials, but also offering less functionality than their desktop counterparts. Audio/video playback and recording works out of the box without turning knobs in the settings. Tablet devices are always “on” and time consuming boot up procedures are eliminated.

The interaction through touch feels, in many cases, more natural and is even fun to use. Ironically, tablets feel mostly snappier than much more powerful laptop computers. For schools this ability to let students interact more naturally via touch is essential. Our evaluation has shown (see section 5) that most students prefer this way of interaction.

4 CASE STUDY: DESIGN AND IMPLEMENTATION

Tablet-based teaching at schools and universities is in an early phase. The community still needs to figure out the best ways to use tablet devices. For this it is necessary to conduct case studies, where tablets can be tested in practice.

For our case study, we have deployed tablets at schools in Baden-Württemberg and Berlin (Germany). We have conducted many in-depth interviews with teachers and students, which provided valuable feedback. It was also interesting to observe the students while learning and interacting with the devices.

In the following, we will explain the design choices, which have been made based on these experiences. We will also explain the software and interactive content, which has been developed during these deployments.

4.1 Basic Software and Hardware

The interfaces of the major tablet operating systems Android and iOS (iPad) are both simple to use. They are, however, NOT designed with a focus on teaching. That is, there is a focus on the concept of apps, whereas we wanted to stress the learning content. That is, the main interface should highlight lessons, lectures and functionality (e.g. taking of pictures). From our initial discussions with teachers and students it became also clear, that the learning content should be organized by subject. In order to meet these requirements for a main interface, we developed a novel user interface for tablet-based teaching (see Figure 1).

Distraction of students by the possibilities of the internet or pre-installed apps (e.g. games or Facebook) turned out to be one of the major hurdles for successful computing deployments. We therefore implemented a Kiosk mode, where teachers could control which apps and functionalities are available to the students.

4.2 Concepts: Learning Content

Learning content is essential, when we want to fully exploit the potential of tablet devices. The lack of content or even of a concept how to use existing content with tablets are the main reasons why some tablet projects have been less successful or even abandoned. This is e.g. the case for the Orestad Gymnasium in Denmark where an iPad deployment has been canceled after 6 months of testing (Andersen, 2012).

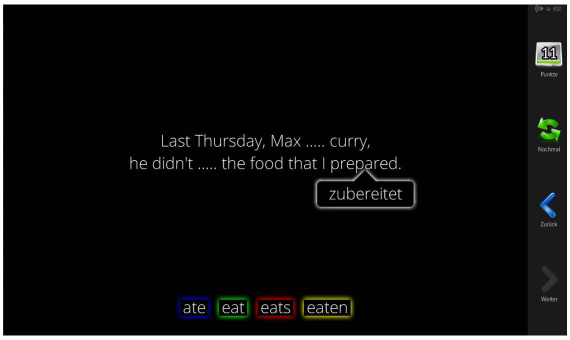
The same is certainly true for other computing equipment as e.g. interactive whiteboards. Those are very widely deployed but seldom used as more than a simple projector.

The goals of our deployments have therefore been in two main areas. First, to provide learning content, which is designed for tablet-based teaching. For this, we developed a novel learning style. With this learning style we combine hearing (ear phones), seeing (pictures and video) and doing (touch interaction) in a way, that makes the learning experience interactive and fun.

We want to provide two examples of our proposed learning style. One example for teaching foreign languages and another for teaching math.

Foreign languages can be taught very effectively with the help of a tablet device. A student can e.g. read through an illustrated story at his own speed. With the help of ear phones he hears the pronunciation associated with the words. He sees and hears at the same time. New words can be learned from the context of the story and the pronunciation can be repeated over and over if necessary. Touch interaction is enabled throughout a lesson and by clicking on a word, additional information or the translation can be displayed.

To further encourage active participation, lessons

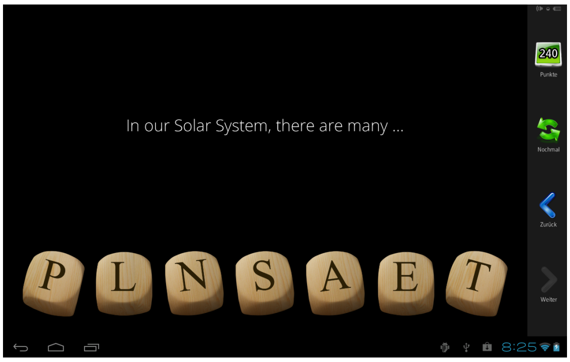


Last Thursday, Max ..... curry,
he didn't ..... the food that I prepared.

zubereitet

Figure 2: Touch-based interaction is possible throughout the lessons. Here an English verb is translated by clicking on it. The translation is highlighted as a speech bubble.

are interrupted after relatively short periods of time with questions and educational exercises or games on the newly learned content. For foreign languages such a game could be a word puzzle where a student has to find the correct spelling of a newly learned word from a provided anagram (see Figure 3).



In our Solar System, there are many ...

Figure 3: Practice the spelling of newly learned words by shuffling the letters.

For math teaching similar techniques can be applied. Content and exercises should always be presented through a problem statement or story. In our sample lesson e.g. we introduce the concept of negative numbers, through analogies in real life or compute the time to travel to the international space station ISS Newly learned facts or rules, should be immediately applied through interactive questions.

Math is often not very popular with students. In our opinion, the main reason for this is, that students get stuck at a problem and fail to follow the rest of the class. This is also very much true for conventional education, where all students have to follow the pace defined by the teacher.

In order to use tablet devices effectively for math teaching, we therefore have to make sure that students can learn at their own pace without getting stuck. That is, the tablet has to react to possibly wrong solutions and intelligently help the student. For this we developed our content in a way, that a teacher can provide hints and pointers depending on the solution provided by the student. As students are interactively tested after short periods of time, common mistakes can be avoided early in the process. For our math sample lesson e.g., we carefully analyzed the answers of 30 students and now provide updated hints and pointers (see section 5).

The second area of improvement is in the area of student motivation. Research in the area of serious games (Klopfer, 2008) (a term often misunderstood by people outside of the education community) shows how motivational elements can help to improve student results. Unfortunately this research has not yet found its way to most schools. We believe that the introduction of tablets should be accompanied by the introduction of elements of serious games. That is learning content should be developed with student motivation in mind.

5 CASE STUDY: EVALUATION

Our deployments at schools in Germany started in May 2012, since then we have gathered usage data and evaluated the teachers' and students' experiences with the devices and software.

The focus of the deployments were students in grade 7 at German high schools. That means students at the age of 12 to 14. We have developed a software, which replaces the main screens of the tablet operating system with a teaching centered user interface. For this user interface, we have created novel interactive content.

The schools have been provided with a complete bundle of hardware, software and a portable server, which allows network and internet access to all tablet devices.

Additionally, we have conducted trainings for the teachers at the schools. Firstly, this has been done to familiarize as many teachers as possible with the usage and user interface. Often teachers see tablets as additional technical burden and realize only later on, that those devices coupled with the right content can make teaching easier. The students learn by themselves and the teachers can concentrate on weaker students needing special attention. Maybe this skepticism comes from the teachers' own experiences with laptops, which are often frustratingly difficult to setup and maintain.

During the trainings, we wanted to introduce the teachers to tablet-based teaching techniques and in particular to the ideas behind the provided interactive lectures. Finally, we wanted to demonstrate what tablet devices are capable of doing (e.g. as a media production device) and in which circumstances they are to be avoided (e.g. writing a long text). We have received valuable feedback from these trainings. In particular, we have received ideas for use cases we did not have in mind initially.

For a more quantitative evaluation of the project, we conducted a formal survey among the students in October 2012. The obtained results will be presented and discussed in the following paragraphs.

The first questions, we asked in our survey, were how tablets compare to conventional laptop computers. We wanted to know whether students prefer the tablets for their learning efforts. Informally, students enjoyed working with tablets. Being able to quickly and intuitively interact with the devices really seemed to play an important role. Our survey underlines this impression with approximately 80% strongly preferring tablets over laptops. Only 4% think, that laptops would be better suited for learning (see Figure 4).

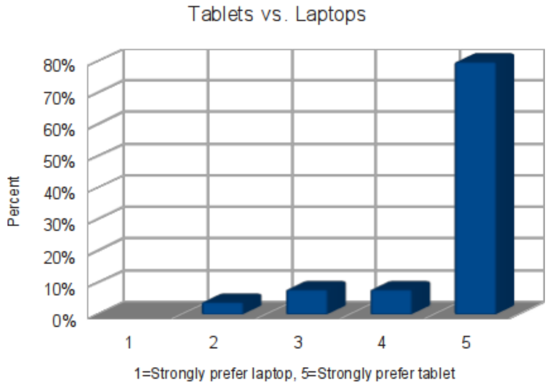


Figure 4: Comparison between tablets and laptop computers. Students mostly prefer tablet devices. Possible ratings were: 1 = strongly prefer laptops, 2 = prefer laoptops, 3 = equally suited, 4 = prefer tablets, 5 = strongly prefer tablets.

A similar result was obtained for the ease of use. Here 76% responded that tablet software was intuitive and simple to use. Approximately 10% think that the learning curve is similar to other computing devices.

Most students also seem to be content with the virtual keyboard with more than 70% of the responses arguing that a physical keyboard is not necessary. Probably, this number very much depends on how the tablets are used in class. In our deployments the focus was on interactive content, where keyboard input is less of an issue.

As far as the self-reported motivation of the students was concerned, an overwhelming 84% of the students were more motivated when working with a tablet than during normal classes. It remains to be seen, whether this is a temporary effect, but at the moment there seem to be a very positive impact in this area.

The interactive questions and games during the lessons were equally well received with nearly 90% of the students considering them essential for their learning progress. Approximately 70% responded that the combination of illustrations and audio greatly improved their understanding and helped them to better remember the content.

Overall 64% of the students are convinced that they have learned more by using the tablets than they would have in ordinary classes. And nearly 90% would like to continue self-learning with the devices at home, e.g. for exam preparation.

The feedback we received from teachers was very positive and even older teachers handled the tablets proficiently after a short training. Teachers also pointed out that short video tutorials as often used in online learning, e.g. (Khan, 2006) provided considerably less learning incentives and students very much preferred interactive lessons.

6 CONCLUSIONS

Based on our observations, we truly believe that, if done right, tablets can vastly improve the process of learning and in particular enable students to better learn for themselves. In this area traditional paper-based books are certainly not optimal.

Our survey has shown that tablets are accepted by students. They feel more motivated and are convinced to learn more effectively. The key, in our opinion, is the appropriate presentation of the learning content. The learning style proposed in this paper is designed for tablet-based learning and focuses on touch-based interaction and student motivation. Further analysis of student responses will help us to iteratively deliver better content.

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Student Autonomy in Online Learning

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Keywords: Autonomous Learner, Learner Independence, Self-directed Learning, Online College Education.

Abstract: Online learning has opened up rich opportunities for unlimited, life-long learning. Continuous professional development, retooling and upgrading expected from members of the knowledge society count on an individual’s developed ability to learn independently. Research suggests a self-sufficient, autonomous learner is more efficient than teacher-dependent student. Though online education offers students significantly greater choices and more freedoms for independent learning compared to traditional campus-based programs, college education based on instructor-centered teaching approach still rigidly controls both the learning content and process thus restricting students’ initiative and flexibility. On the other hand, there are many students who do not possess the necessary independent study skills and dispositions, and are fearful of engaging in independent learning. Online learner autonomy, however, is critical for a person’s continuous development and learning efficiency, and the present research investigates students’ perceptions on the matter suggesting ways to promote students independence within a college class.

1 INTRODUCTION

It is critical for the 21st century knowledge society that the educational system cultivates autonomous, life-long learners capable of independently constructing knowledge and developing skills to effectively adapt to changing markets and compete in a challenging global environment. According to Hargreaves (2003, 65), “the things most prized in a knowledge economy - creativity, spontaneity, deep understanding, critical thinking and the development of multiple forms of collective intelligence” are the qualities that only a conscious, autonomous learner possesses.

Adult learners, who make up the majority of online classes, have an acute need and considerable motivation for independence (Merriam, 2001). Knowles (1975) suggests that adults are intrinsically motivated by internal incentives and curiosity, rather than external rewards. Intrinsic motivation is the key to independent learning (Gagne and Deci, 2005). Therefore adults more than any other category of learners deserve freedom in online classes. The reality of college education, regrettably, demonstrates the opposite.

Creating conditions for nurturing an independent, autonomous learner in web-based knowledge environments, particularly in online college courses, requires a change in pedagogic perceptions, certain methodological modifications, new understanding of the instructors’ and learner’s roles, superior dispositions and advanced skills both from the instructor and the students. Those dispositions and skills for students include accountability for their own learning, capability to reflect on and critically assess their own learning, and confidence in their abilities, which is supported by their strong learning habits and experiences. In addition, students’ basic readiness, which includes a set of fundamental skills and various literacies, is vital for successful autonomous learning.

The current paper attempts to identify major factors affecting students’ independence and autonomy in online college classes, presents the current authors’ findings, both theoretical and practical, on college students’ autonomy from the research conducted in online postgraduate teacher preparation programs at National University, USA in 2012, and offers some insights into student independence and autonomy, as well as into student learning in general.

2 LEARNER AUTONOMY IN ONLINE ENVIRONMENT

One of the ultimate goals of any educational system is to develop autonomous, life-long learners who are capable of both independently and collaboratively resolving life and job problems (Hargreaves, 2003). Such a goal can be achieved through fostering learner autonomy, which Moore (1984) defined as "the extent to which in the teaching-learning relationship, it is the learner rather than the teacher who determines the goals, the learning procedures and resources, and the evaluation decisions of the learning program" (p. 85). Autonomous learners are more successful learners who achieve their learning outcomes with the best efficacy (Albert, 2007).

Autonomy in learning is immediately related to innovation, creativity and self-efficacy. Buvoltz (2008) argues that promoting student autonomy is pedagogically sound, especially with regard to adult learners.

Developing student independence and autonomy in learning is thus one of the major tasks of education (Bembenutty, 2011), (Dillner, 2005), however little has been done to implement it. Everything interferes with this task in the college: the curriculum, course syllabus, course structure, instructor's authority, teaching habits and tradition of classroom management and control; finally, educational standards and formal tests. The regulations and practices of organized class provide students with poor preparation for highly innovative, flexible and team-based knowledge economy where routine is the enemy of innovation and risk (Hargreaves, 2003, p. 14).

The CIEL Handbook states, "Learner autonomy indicates a number of dimensions in which learners move away from dependence on the teacher and:

- Take responsibility for their own learning and learn to learn;
- Involve themselves in an interactive process in which they set short and long term learning objectives, reflect on and evaluate progress" (CIEL Handbook, 2000, p.5).

Such an approach requires a new vision of teaching and learning where the focus will be on helping students maximize their autonomy. This leads to the idea of learner-centered education which is directly related to the principles originating from the views of Dewey, Piaget, and Vygotsky, and to the concept of independent or self-directed learning (Hiemstra, 1982). The principle of learner autonomy correlates with learner-centeredness of education, social constructivism and collaborative approach.

Online learning by definition is a form of independent study, even if an institution delivers it, and promotes self-directed learning due to its own nature. An online learner, being separated from the school and instructor by space and time, gains the benefits of a more convenient self-study environment, individual learning style and pace, flexibility of scheduling, together with access to unlimited internet resources, but loses organized, mandatory, bonding face-to-face classroom activities (Serdyukov and Serdyukova, 2012, 42), which may affect their ability for autonomous learning.

Regrettably, online students generally have limited communication with the instructor, fewer opportunities to work collaboratively with their peers, do not usually have continuous and engaging face-to-face interactions with other participants of the learning community, and do not receive critically important instantaneous feedback, which is readily available in a live classroom environment. Moreover, lack of F2F interactions does not foster the development of personal relationships in the class, which inhibits the feeling of belonging to a community and trust among peers. This may negatively affect learning outcomes as learning is a social activity which requires participation in a social group (class) and interaction with members of the group (Vygotsky, 1962), (Bandura, 1997).

ClassLivePro, SKYPE and other telecommunication technologies may partially ameliorate this situation, however they do not significantly compensate for the dearth of true connection. Another option to develop a learning community is offered in blended or hybrid classes. Yet, the necessity to attend live classes at scheduled times definitely restricts student independence and undermines the asynchronous learning mode.

Social networking presents a unique opportunity for independent, flexible and collaborative learning providing students with an individual learning space and communication capabilities outside rigid course frameworks. Moving a part of the learning process into the freedom of social networking is a viable option for boosting independent learning, at the same time integrating the student in a rich communal space. The new model of contemporary learning can be portrayed as a loose organization of a number of stakeholders, where a student remains autonomous even when connected to the college and instructor, while participating together with other students in the external learning community created for a particular course.

3 INVESTIGATION OF ONLINE STUDENT INDEPENDENCE

One of the goals of contemporary technology-based education is to engage students in truly independent, life-long learning where the motivation is to attain excellence in learning that leads to higher performance on the job. To understand what contributes to and what interferes with independent learning in online classes we investigated students' attitudes and self-evaluations related to independent learning. A survey was designed for this study and run in 14 groups of the postgraduate teacher education program in the School of Education at National University in 2012 using a specially developed questionnaire that addressed key issues affecting student independence and autonomy in online classes. In all 65 students completed the questionnaire. Sample standard deviation was calculated for the first two sets of data (tables 1 and 2). The present paper will focus on the survey's major findings.

First, students were asked two questions:

1. Do you prefer to learn *on your own* (*independently, without enrolling in a college program*) or in an *organized college class*? (learning format)
2. When you take a college class, do you prefer to study *alone (independently*) or to *collaborate with others*? (learning style)

According to the responses to the first question (Table 1), the majority of students – 62.0% prefer to take organized college classes, and only 34.9% would prefer to learn independently, outside college, while 3.1% would be comfortable in either format of learning. It appears working adult students are generally not enthusiastic about learning independently.

Table 1: Student preferences for the learning format (%).

Options\ Format	Independent learning	Organized learning	Both
Preference	34.9	62.0	3.1

(Sample standard deviation = 3.4)

Based on their responses discussed further, many students obviously rely on a straightforward course structure and unambiguous organization of the class, direct leadership, support and even pressure from the instructor. So they are willing to trade the benefits of independent study for the security of instructor-facilitated class, thus demonstrating their dependence on outside factors for their success rather than on their own skills and abilities. It may be suggested that in an online learning environment, where they study predominantly autonomously due to its nature, some students feel lost and unsure of their ability to cope with course demands. The need in externally imposed structure, organization and obligation might be explained by students' lack of confidence in their abilities to accomplish their learning independently which comes, as the survey demonstrated, from poor learning habits and time management skills, lack of diligence, persistence and effort, as well as insufficient learning skills (reading, writing, critical thinking, and research), low motivation, deficient self-evaluation and scant support from family and employers.

Surprisingly, within a college class 76.9% of the same students prefer to study independently, while only 18.5 % do not mind collaborating with their peers and even fewer, 4.6%, enjoy both options (Table 2).

Table 2: Student preferences for the learning style (%).

Options\ Style	Independent learning	Collaboration	Both
Preference	76.9	18.5	4.6

(Sample standard deviation = 5.1)

These numbers imply that even when students are taking an organized, instructor-facilitated class, the majority of them prefer to do their work individually. This was quite an unexpected finding in view of the growing trend for collaboration and cooperation in college education. Team work, according to students' responses, is fraught with difficulty in organizing and managing and characterized by distraction and uncertainly. Moreover, students do not have confidence in their potential partners and feel uncomfortable to depend on the people they don't know.

So, though the majority of students prefer to take classes in an organized university program, an even higher percentage of them try to avoid studying collaboratively and prefer to work independently. This paradox may be a manifestation of students' individualism which, however, is not equivalent to autonomy supported by self-sufficiency and self-efficacy. Therefore these students count on the college and instructor for guidance and support, while rejecting collaboration for fear of being failed by potential partners.

Current research identified a number of challenges students face in learning that interfere with their success the class. Students expect a clear structure and organization of the course; reasonable, meaningful and explicit course requirements and expectations, and the instructor's more effective and personalized teaching style. At the same time, students point to their own flaws that affect their learning, such as attention issues, poor time management skills, low motivation, lack of confidence and independent learning skills.

The current research showed the ways to make significant improvement in the courses to develop student autonomy:

- Fewer restrictions and prescriptions of what and how to do;
- The right for students to critically review the course, offer suggestions for its improvement, identify their personal goals and participate in defining their own learning trajectory;
- Meaningful, developmental and creative assignments that do not impose heavy constraints on implementation;
- Availability of continuous, open and productive interactions, relationships, communication and collaborative group work in the class;
- Effective, specific, clear and prompt assessment of student performance, supportive feedback and objective evaluation together with effective self-assessment and reflection;
- Opportunities to offer and execute their initiatives in the course, modify some assignments, freely select implementation strategies, suggest their own activities, apply their professional and life experiences, and take part in situations requiring their demonstration of leadership qualities;
- A space outside the course where students can communicate and collaborate on course assignments through social networking.

The instructor's responsibility is to provide continuous individual support and guidance in developing student autonomy through effective facilitation the interactions in the course. There are numerous other opportunities in online classes to offer students learning tasks and activities that foster their independence.

4 CONCLUSIONS

Developing autonomous learners is clearly one of the main goals of education, particularly at the college level. As the current research demonstrates, however, the majority of our online students prefer organized, teacher-facilitated college classes to independent learning. At the same time, within collective college group environments the greater part of students prefers to study individually. In both cases many students lack self-confidence as well as trust in their classmates. Research also points to an inadequate student preparation for advanced college studies and, in some cases, flawed dispositions.

Further research involving students of various levels of study (undergraduate, graduate and postgraduate) will help identify other critical factors as well as effective methodological tools and techniques that are instrumental for enhancing students' autonomy in online college classes. The effect of social networking in college education on encouraging student autonomy deserves special attention.

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Serious Games for Music Education
A Mobile Application to Learn Clef Placement on the Stave

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Keywords: Music, Education, Mobile Applications.

Abstract: According to recent researches, gaming can be used in educational contexts to improve learning processes. In this work, at first serious games are introduced by defining their key features, then their applicability to the music education field will be discussed. Finally, the paper will present a specific case study focusing on real-time solfège of scores with frequent clef changes. The resulting pedagogical game, called *iClef*, has been designed and implemented to run on mobile devices such as the iPhone and iPad.

1 INTRODUCTION

Recent research has shown that gaming can be profitably used in educational contexts, in order to make the learning process both effective and amusing. Serious games (Abt, 1970) are designed for purposes that go beyond mere amusement. Like any game, they are intended to entertain users, but their main goal is usually to train and educate them. In other words, the recreational aspects of serious games act as a sort of Trojan horse to convey computer-supported education. The effectiveness of games as teaching tools is due to their potential to engage players.

The term "serious game" was actually used long before the introduction of computer and electronic devices into entertainment, but our concern in this article is with the application of information technology to educational processes. The article (Zyda, 2005) provides an up-to-date definition for serious games, depicting them as "mental contests, played with a computer in accordance with specific rules" that use entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives.

This paper addresses a specific field, namely music education. Serious games could be applied to this domain for a number of different purposes. For instance, it is possible to teach the key concepts of music theory and instrumental practice through *ad hoc* hardware and software frameworks based on selected music materials. The huge success of entertainment-oriented applications like the celebrated *Guitar Hero* (Arsenault, 2008), released for all the principal gaming platforms and PC systems from 2005 on, witnesses not only the pedagogical but also a huge commercial interest towards this kind of products.

In order to provide a comprehensive discussion of the matter, Section 2 presents a brief review of related works, whereas Section 3 is devoted to fixing specific goals for our serious game. Finally, Section 4 describes *iClef*, namely an example of music serious games implemented by the authors.

2 RELATED WORKS

The scientific literature about computer-based serious games somehow dealing with music is very rich. Researches and implementations range from simulated instrumental practice to advanced ear training, from alternative ways for music composition to graphical representation and analysis of scores, from gesture recognition to motion tracking techniques aiming at controlling music and/or audio parameters. Moreover, the iPhone, iPod and other popular mobile devices intrinsically support music digital libraries, thus their environment encourages applications where music can be employed in an unconventional way. Since the field is so wide, we will narrow our discussion to mobile-oriented applications related to music edutainment and ear training.

A first category includes the huge family of applications either simulating traditional music instruments or implementing brand new ones. For example, (Wang, 2009) describes the so-called *Smule Ocarina*, i.e. a wind instrument designed for the iPhone.

In this mobile musical artifact, the interactions of the ancient flute-like instrument are both preserved and transformed via breath-control and multitouch fingerholes. Besides, the onboard global positioning and persistent data connection allow the users to listen to one another, thus creating a social experience. Mobile music making is becoming both a relevant field of research from a technological point of view and an evolved expression tool in an artistic perspective, as demonstrated in (Tanaka, 2004). Initiatives such as *Momu* - a mobile music toolkit (Bryan et al., 2010) - and MoPhO - the Stanford Mobile Phone Orchestra (Oh et al., 2010) - witness this new tendence.

In our short review, it is worth citing researches about gesture, motion capture and physical metaphors in designing mobile music performances. An example is contained in (Dahl and Wang, 2010), based on the metaphor of a sound as a ball. Exploring the interactions and sound mappings suggested by such a metaphor leads to the design of a gesture-controlled instrument that allows players to "bounce" sounds, "throw" them to other players, and compete in a game (called *SoundBounce*) to "knock out" others' sounds. The soundscape is designed so that all actions and changes of state have audible correlates, allowing both players and audience to perceive what is happening without any explicit visual information.

In the music education context, there are many interesting initiatives and applications based on mobile devices. For instance, (Zhou et al., 2010) describes the experience of *MOGCLASS*, namely a system of networked mobile devices to amplify and extend childrens capabilities to perceive, perform and produce music collaboratively in classroom context. Another relevant example is represented by *Rhythmatical* (Moorefield-Lang and Evans, 2011), designed to be an educational application for the iPhone and iPod Touch that conveys mathematical topics via musical, rhythmic, or movement interactive techniques.

With respect to the applications and approaches reviewed in this section, our work is focused on a very specific matter, often referred to as *clef reading*. In this sense, our software takes advantage from the mentioned experiences as regard the use of mobile technology and interface design.

3 HOW TO PRACTICE SIGHT READING IN DIFFERENT CLEFS

In modern notation, usually three clefs (namely three graphical symbols) are used to notate music, i.e. *G*, *F*, and *C*. Each type of clef assigns a different reference note to the line on which it is placed. Modern notation often assigns a standard position to the three cited clefs; nevertheless, in order to facilitate writing for different tessituras, any of the clefs may theoretically be placed on any of the lines of the staff. This practice was common in renaissance and baroque music, above all in vocal pieces such as motets and madrigals. However, modern instrumentation and orchestration texts, such as (Blatter, 1997), suggest their use for some instrument scoring: e.g. the alto clef is a common one for viola, as well as the tenor clef is typical of trombone scores.

Since there are five lines on the stave, and three clefs, it might seem that there would be fifteen possible clefs. Six of these, however, are redundant clefs, so only nine possible distinct clefs are allowed and have been historically adopted: the G-clef on the two bottom lines, the F-clef on the three top lines, and the C-clef on any line of the stave except the topmost, which is deprecated. Each of these clefs has a different name based on the tessitura for which it is best suited: Treble, and French violin clef (symbol: G-clef); Bass, Baritone, and Sub-bass clef (symbol: F-clef); Alto, Tenor, Baritone, Mezzo-soprano, and Soprano clef (symbol: C-clef). The keys listed above are graphically shown in Figure 1.

In Italian conservatories, sight reading of scores containing frequent clef changes is one of the tests the final exam of *Music Theory and Solfège* is made of. Figure 2 provides a hand-written example of this kind of examination. Since for most young music students practicing clef reading is an unusual and dreary activity, our purpose is providing them with a serious game oriented to this specific task. The mobile application described in the next section, called *iClef*, should do the job.

4 CASE STUDY: LEARNING CLEFS ON A PORTABLE DEVICE

iClef is a serious game which addresses the problem of correctly reading note pitches when the clef is not only a commonly used one, such as a treble or bass clef. The interface shows notes with no rythmic indication, written on a staff that carries randomly selected clefs, at an increasing metronome rate. In order to help the user, smaller noteheads suggest the next notes written in the current clef. The user has to choose the right corresponding key on a piano-like keyboard as quickly as possible. The interface

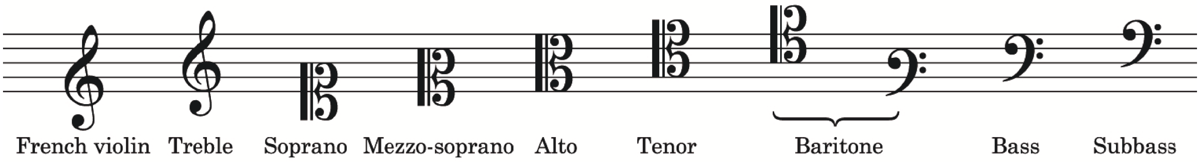

Figure 1: Clef types and their placement on the stave.

Figure 2: An example of final examination from an Italian conservatory.

Figure 3: The interface of *iClef*.

is shown in Figure 3.

4.1 Gameplay

The key idea is providing the player with a very simple graphical interface, where the main game controls - namely the music keys - are located on the right side and are easily accessible through the thumb. In fact, the user must be able to give a prompt response to the notes graphically shown in the left panel.

The game is organized in a number of levels, each one presenting an increasing degree of difficulty. It is worth underlining that melodies are not predefined, but they are computed in real-time by taking into account both music-related rules and player performances. The former aspect is detailed in the following subsection, where some notation obstacles are listed.

After a given number of mistakes, the player is not allowed to access the next tier.

4.2 Levels and Scoring

Like any other game, in order to catch the attention of the player and to stimulate his/her abilities, *iClef* presents increasing degrees of difficulty.

A first aspect is the overall metronome, which establishes through its beats when a new note should appear. Needless to say, a slow metronome is adequate to the very first levels, whereas it becomes faster and faster as the game goes on.

Besides, the number of clef changes can dramatically impact on the degree of difficulty, so the rate increases from level to level according to $n = (11 - l)$, where n is the number of notes occurring between two clef changes and $l \in [1..10]$ is the current level.

Another aspect taken into account is melody complexity. In fact, a step-by-step melody (often known as *conjunct motion*) is intrinsically easier to read than a line with wide intervals. In this case, the number of scale grades that separate the endpoints of the (either ascending or descending) interval is $i \in \mathbb{N} : i \leq l$. As an example, at level $l = 1$ only 1-grades (ascending and descending second) intervals are allowed. There is a relevant exception to this rule: when a clef change occurs, the random interval is not related to the previous note in the sequence, but to the base line of the new clef. Only in this case, unison is allowed.[1] For instance, at level $l = 1$ and under a treble clef, the first pitch is one of F, G, or A, independently of the previous pitch under the old key.

Since accidentals and ledger lines make the reading exercise harder, they are progressively introduced in the higher levels. As regards the former aspect, for $l \in [1..4]$ the algorithm chooses only natural notes, for $l \in [5..8]$ single accidentals (i.e. sharp and flat) are introduced, and finally for $l \in [9..10]$ double accidentals may appear.

During the gameplay, the interface provides a variable number of clues which provide in advance information about the next notes (graphically indicated by small symbols). In the easier levels clues are two, but they gradually disappear in higher levels.

All these aspects are conveniently mixed during

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[1] Please note that in general terms the concept of interval implies the distance between two pitches, whereas in this case the "unison" occurs between a real pitch and the virtual pitch indicated by the clef position.

the gameplay, so that the task becomes harder and harder.

The player's performances are mainly measured in terms of right-answers rate, and this is the key aspect to extend play to higher levels. However, scoring is influenced also by his/her reaction time: a prompt response results in a higher score for the current note, and a series of quick responses gives bonus points.

5 CONCLUSIONS AND FUTURE WORKS

The present paper has addressed the issue of serious games' application to a specific domain of computer-supported education, namely music training. Unlike many other approaches, here the professional vocation of the entertainment activities is stressed. In fact, the target is represented by young students who attend music conservatories rather than video gamers fond of music.

This serious game allows the improvement of score following for some instruments - e.g. violas and trombones - and for specific repertoires as early vocal music, whose typical ensemble is *Cantus*, *Altus*, *Tenor* and *Bassus* (Kurtzman, 1994). The resulting pedagogical application has been tested on several classes of music students. In all cases, such an approach has produced a high level of amusement and involvement in students, which has been evaluated through blind questionnaires. This is a relevant result for our research, since clef reading is usually considered either an annoying or a challanging activity. Needless to say, relevant differences emerged depending on the age and the degree of music students.

Future works may take advantage from a wide user acceptance test, paying special attention to aspects such as usability, learning effectiveness and player amusement. Besides, we are interested in releasing such a game for other platforms, including a Web version. Finally, other aspects of music theory (e.g. rhythmic ear training or music dictation) could be investigated.

ACKNOWLEDGEMENTS

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Smart ePortfolio System

Experimental Prototype Testing in Living Lab and Further Artificial Intelligence Implementation Design within ePortfolio System

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Keywords: Information System, ePortfolio, Assessment, Critical Thinking, Reflection, Collaborative Learning, Artificial Intelligence.

Abstract: This paper's aim is to pay attention to actuality of new information system development in a form of engaging and reflective ePortfolios. Main accent in the system is put on an encouragement of learners' collaborative efforts in teams, activate their critical thinking and reflection, and as a result, achieve better learning outcomes and competencies. The author introduces experimental ePortfolio system prototype and its testing results in Living Lab environment in Riga Technical University. A notion of making ePortfolio system more reflective, interactive and intelligent brings further proposals of development additional artificial intelligence tools which might be embedded into the system.

1 INTRODUCTION

New technologies change our habits, work procedures, leisure hours, communication opportunities, and our life. These changes bring new breath also in educational environment; educational paradigms switch over from teacher-centric to student-centric, from mainly individual to mainly collaborative interaction; learners are oriented on development of their critical thinking skills, enhancement of creativity, wider use of technology in knowledge acquisition process (Churches, 2010). It allows students to be better prepared for nowadays challenges.

Educational sphere demands for effective managerial work, assessment and self-assessment processes to improve learning outcomes (Goldspink, 2007). Progressive educators try to find the most useful and suitable educational methods and tools to satisfy lifelong learning needs. They are seeking for new ways to make learning process more engaging, motivating, creative, and effective. Information technologies provide invaluable support in introducing of new teaching and learning methods. Occasionally scientists create new and modernize existing educational tools and systems; and this creativity process often is advanced by scholastic institutions requests.

ePortfolio systems might be considered as new effective competence enhancement instruments. They also have changed their own nature: from simple showcase forms (in the past) to motivating workspace environments (nowadays). These two different natures or faces of the ePortfolios indicate two different senses: ePortfolio as a product in the first case, and ePortfolio as a process in the second case (Barett, 2009). Showcase form of ePortfolios still has prevalence. Nevertheless, more and more educational institutions seek for more powerful end effective ePortfolio systems to improve learning outcomes.

Reflection, critical thinking, ability to work in collaborative and tied to time settings are considered as important factors to be able to enhance learners competencies. Excellent results might be achieved by „involving students in doing things and thinking about what they are doing" (Bonwell and Eisen, 1991). Stimulation of critical thinking and reflection could be considered as a fine solution to meet the competence enhancement demands.

This paper shows the latest ePortfolio developments realized by Distance Education Study Centre, Riga Technical University (DESC RTU), examines Living Lab testing and research results related to effectiveness of experimental ePortfolio system prototype, as well proposes a new generation ePortfolio system algorithmic model.

2 DEVELOPMENT OF THE E-PORTFOLIO SYSTEM

2.1 Testing of ePortfolio System Prototype in Living Lab

Keeping in mind, that Living Labs are intended to involve users in the innovation process, knowledge sharing, exploration, experimentation, assessment, and co-creation (Pallot, 2009), created engaging scaffolding ePortfolio system was tested in RTU DESC Living Lab in study year of 2011/2012 (Gorbunovs, Kapenieks, A., and Kudina, 2012).

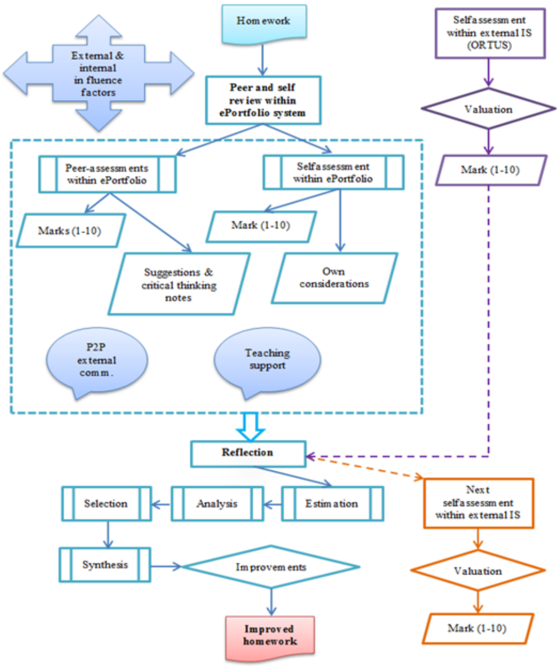

Figure 1. Simplified scheme of the ePortfolio system's algorithmic model (Gorbunovs, et al, 2012).

Experimental ePortfolio system (the left side of the Fig.1) embodies environment where students after submission of their accomplished homework (tasks) are divided in teams (groups) of four participants each and asked to acquaint themselves with other group members accomplished homework, reflect, assess them both in scores and in a form of critical thinking notes and suggestions, as well make self-assessments about own accomplishments and possible shortages. Students have a possibility to see group member names against their achieved assessment results: scores, critical thinking notes and constructive suggestions. To clarify details, students also can establish internal and external communication links. These processes are monitored by tutors who can give necessary advice and assistance. Students are also asked to reflect on own work and his/her group members feedback in a form of critical thinking notes and suggestions, take a note of tutors advice, estimate the data and put them against own calculations, analyse information, select appropriate conclusions, add something well-formed or synthesize creative ideas. All this might lead to increasing of the number of improved homework and growing better learning outcomes.

2.2 Results and Progress Report

From 203 joined the BPOM ("Business Planning for Open Markets") course students only 173 learners finished it. Drop out reasons vary but none of them are caused by BPOM course issues. 56 learners took part in all group-working activities (5 tasks) within ePortfolio system, 16 students also were very active – they participated in four group-working activities, 19 students were rather moderate – three group-working activities, 27 students were less active – two activities, 39 students were inactive – only one group-work was done, and 97 did not participated in any of ePortfolio group-working activities. As the participation in ePortfolio activities for students was not compulsory, shown numbers of participation activities is rather high.

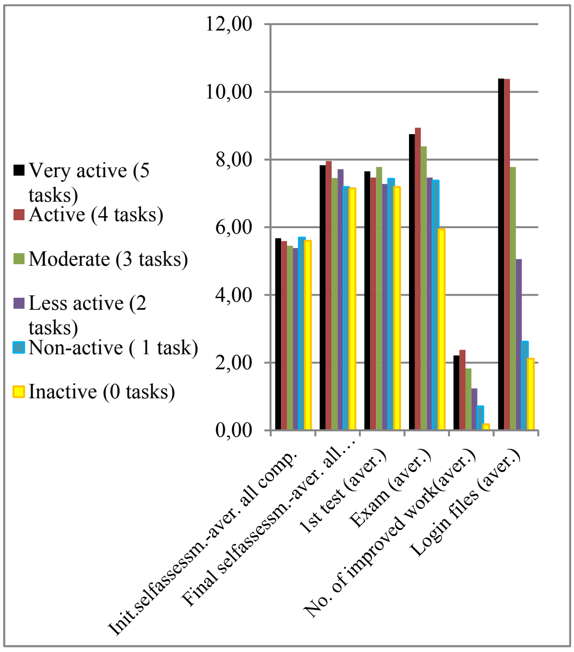

Figure 2: BPOM competence (on average of seven) development correlations with ePortfolio activities.

ePortfolio prototype testing results in Living Lab show (for example, Fig. 2) that activities within

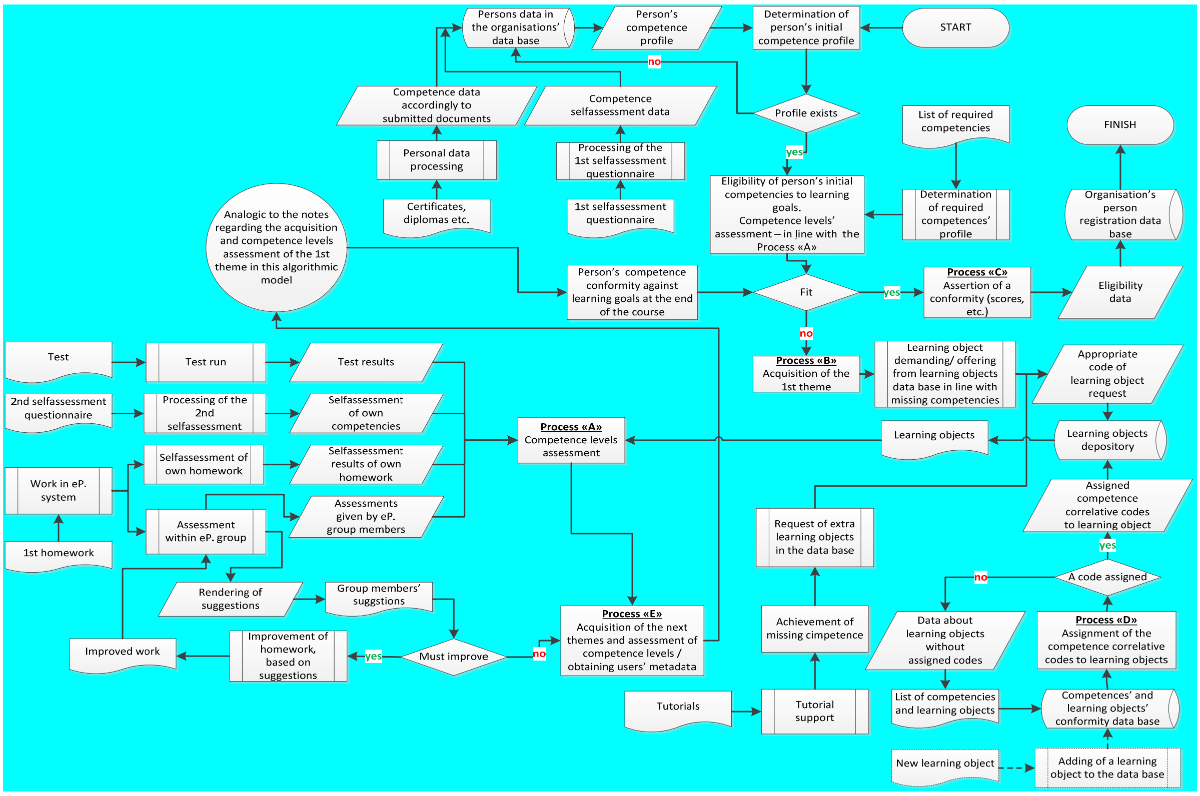

Figure 3: Proposed ePortfolio system's algorithmic model.

ePortfolio system have direct correlations with students' exam results and increased level of their competencies. Similarly, the number of improved homework also has direct correlation with activities within ePortfolio system, i.e. the number of ePortfolio login files. More active students much more take part in offered group work activities. It is clearly that learners' reflection on critical thinking notes and constructive suggestions leads to a creativity, synthesis and competence development. As a result, the number of corrected, slightly improved or crucially processed works depends on users' activity level within ePortfolio system. All in all there were received 312 improved works. From them the second homework was improved 78 times, the third homework was improved 66 times, the fourth homework was improved 65 times; and the fifth homework was improved 103 times.

In the current study year of 2012/2013 experimental ePortfolio system is improved by adding new features, such as automation of students' homework submission to the ePortfolio system and automatic ePortfolio group formation based on a sequence of submitted homework accomplishments. Nevertheless, the challenging issues regarding development of a new generation ePortfolio system, i.e. smart ePortfolios, still remain.

2.3 Initialization of Artificial Intelligence Methods

New smart ePortfolio system might be created by enrichment of existing system algorithmic model with artificial intelligence (AI) traits. The system will start by assembling person's achievements data (certificates, diplomas, self-assessments, exam results and so on) to form a person's competence profile (Fig. 3) and determination whether the person's competence profile exists or not. If the profile does not meet fixed requirements (there is no competence markers within a cell), the system will encore the procedure. If the profile exists, an eligibility of the person's initial competences against learning goals will be assessed. Further the system will analyse whether the person (i.e. person's competence profile) fits these requirements or not. In a positive acknowledgement an assertion of conformity will be issued. It means that the person does not need any learning for particular case.

Otherwise, the person will be asked to apply for the course. The system will issue corresponding learning objects and/or links allowing acquisition of the course. The learner will accomplish the first home-work and test, make self-assessment and assess ePortfolio group members' homework which will include marking of required assessment criteria and formulating an opinion in a form of constructive recommendation. Based on these critical thinking notes the learner will reflect and decide whether peers' suggestions are useful or not. This decision may lead to further homework improvement and creativity actions. Improved work again will be input into the system and exposed for analysing and assessment by ePortfolio group participants once more. The student will be able also do not take any homework improvement actions if he/she concludes that ePortfolio system group members' remarks are not constructive and useful. In both cases after completion of the first theme the next course module will open.

Test results and competence assessments data further will be assembled and analysed in order to state the value of gained competences. Depending on achieved competence level appropriate learning object code will be generated; and the learner will receive necessary learning objects with assigned codes. Initial competence assessment is essential. Processes, such as an assignment of the competence correlative codes to the learning objects and the assignment of the learning objects' self-correction rates, play significant role in ePortfolio system's AI decision making process. They allow finding the most suitable learning path in specific case.

3 CONCLUSIONS

Created collaborative ePortfolio system prototype verified our expectations regarding system's positive impact on learning outcomes. Activities within ePortfolio system have direct correlations with students' exam results and increased level of their competencies. Students are encouraged reflect and think critically. Their creativeness grows by virtue of active participation in collaborative activities within ePortfolio system.

On the other hand, an analysis of students' self-assessments within university's study portal "ORTUS" displayed learners' inability to make self-assessments by objective considerations: many students had a lack of confidence, and, as a result, their initial self-assessment marks were far from real competence levels. It took time to get some confidence. Hardworking students enabled steady progress, which allowed them to acquire required competences and achieve remarkable final exam results. Other students overleapt themselves. Starting from the second course module they made corrections in self-assessment questionnaires. Activities within ePortfolio system influenced more precise adjustment of these changes.

Proposed artificial intelligence methods and tools to be embedded into ePortfolio system might look promising. Both students and teachers might gain by its use. There will be further considerations, developments and adjustments (creation of system modules, generating competence correlative codes to the learning objects, etc.) needed to build up the new generation ePortfolio system – smart ePortfolios.

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A HackIt Framework for Security Education in Computer Science

Raising Awareness in Secondary School and at University with a Challenge-based Learning Environment

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Keywords: Computer Science Education, Challenge, Game-based Learning, Framework, Security, Higher Education.

Abstract: HackIts are short computer security challenges which are often Web-based. Their purpose is to raise awareness for common security issues by showing different intrusion possibilities in today's computer security. We present a framework that allows security education in a safe, modular, and motivating way, with the possibility of flexible and low-cost integration into existing curricula. By solving challenges within this learning environment, the leaner gets confronted with IT security problems and learns how to prevent them.

1 INTRODUCTION

Today's society relies more and more on communication and storing data online, which results in security aspects becoming more and more important. To increase the focus on the growing importance of security aspects during Internet usage and software development, the HackIt!-Framework that will be introduced in this paper, puts the learners in the attacker's perspective to raise awareness for this topic.

In a game-based learning environment, the students learn how to identify and counter common security vulnerabilities. Each challenge (called a HackIt) is one level in the whole set of challenges of a course and addresses one or more security issues. They have to be discovered and exploited by the learners to solve the challenge and to advance to the next one.

The HackIt!-Framework is suitable for and aiming at secondary school students and university students in their early semesters. Both of them can use the framework during workshops, which are offered by our research group (Bergner et al., 2012) (Apel et al., 2012), or as exercises during or after lectures. After this, the learners should have a keen sense of security problems in today's Web software.

2 DESIGN DECISIONS

When making the first design decisions for the HackIt!-Framework, we had several aspects in mind that required consideration. Some of these are the flexible intergration into existing curricula, the importance of fun and motivation while learning and the practical relevance und application of security principles. In the following we will describe these considerations.

2.1 Flexible Curricular Integration

Safe software and cautious usage of current electronic media are vital for a risk-aware participation in modern life. This is especially important for computer science students, who will be future developers of those systems. So, integrating security aspects into computer science education is an important, but also complicated task. As Yang pointed out, most educators lack the knowledge needed for integrating security aspects into existing courses (Yang, 2001).

Nevertheless, we want to provide the possibility to integrate these important aspects flexibly into appropriate courses, which can stem from various different areas of computer science (Border and Holden, 2003). Due to limited time and resources in designing courses, we decided for a modular approach, which is not directly linked to a specific lecture or workshop (Edge and Stamey, 2010) as further described in section 2.3.

2.2 Aspects of Games in CS Education

Within the field of computer science education, the interactive learning style of game-based learning mostly invites to use this approach for teaching algorithms.

Shabanah and Chen list the following benefits of using serious computer games for algorithm learning: Computer games are popular, interactive and competitive and they utilize entertainment and simplify assessment (Shabanah and Chen, 2009). These characteristics are easily applicable to other areas of computer science education as well. Therefore, we will use a competitive game-based approach to motivate learners while playing the different challenges of the HackIt!-Framework.

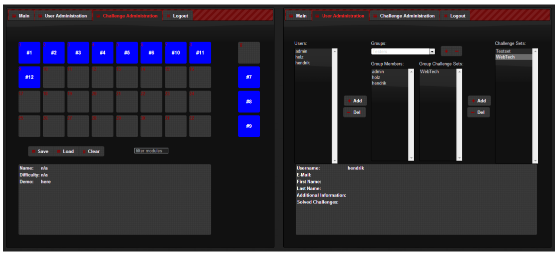
2.3 Target Groups

The HackIt!-Framework provides a platform for a plethora of different security challenges, as described in section 3.1. Thus, it is applicable for different target groups. The basic content of the framework is intended for students that visit the InfoSphere - the students' lab for Computer Science at RWTH Aachen University (Bergner et al., 2012). These school students are mostly not yet familiar with the concepts of computer and information security. This framework helps the students to get informed about the responsibility to sanitize their source code. By confronting them with common mistakes and risks that arise thereof, they will be sensitized to avoid these mistakes in their future implementations.

Besides the usage for school students, this framework provides ideal conditions for higher education. Computer science students, e.g. participants of a Web-Technologies lecture, get the possibility to solve and maybe to develop challenges as part of their learning process. Especially the design and implementation of challenges support the learners in creating safer software (Pothamsetty, 2005). Depending on their prior knowledge, the framework allows to flexibly build individual task-sets of different difficulties.

3 FEATURES OF THE HackIt!-FRAMEWORK

The HackIt!-Framework will provide its users a full-fledged modular system for creating, modifying, and supervising HackIt!-based security challenges. It ships with an extensive administration panel, allowing the lecturer to modularly create a customized set of challenges via drag and drop (see Figures 1). Additionally, users will be able to request hints for the challenges, which, depending on the administrative settings, will cause scoring penalties or not. Optionally, the administrator can enable a high score for this challenge set, allowing users to view the progress of their classmates, which encourages competitive gameplay.



Name: n/a
Difficulty: n/a
Demo: here

Username: hendrik
E-Mail:
First Name:
Last Name:
Additional Information:
Solved Challenges:

Figure 1: The tabs for challenge and user administration. Learners can be grouped together and challenges can be assigned to them.

3.1 Challenge Types

All challenges are categorized by their type, providing a pleasant overview and the possibility to easily create mixed challenge sets.

- **Basic.** These challenges contain simple plain JavaScript challenges and are mostly used to warm up and give the user a basic understanding of JavaScript password checks.
- **Realistic.** Realistic challenges confront the user with real-world problems of today's software. They include but are not limited to SQL injection and cross-side scripting (XSS) due to missing input sanitization, as well as htaccess security and weak or commonly-used passwords. Some missions will also focus on the differentiation between legit and phishing mail, amongst others preventing the user to fall prey to fraud attacks.
- **Review.** During these challenges, the user gets confronted with the source code of a particular security feature and is responsible for finding the vulnerability or problem in it. These challenges might get extended to allow the learner to repair them.
- **Advanced.** These kinds of challenges require ssh key breaking, reverse engineering of self-modifying executables, custom hash breaking, and/or deep domain knowledge and should not be used for common school exercises, or at least be marked as optional. There are currently only a few challenges of this type with the purpose to challenge participants that already solved everything else.

These categories cover most of the top ten security issues, published by the OWASP Top Ten Project[1].

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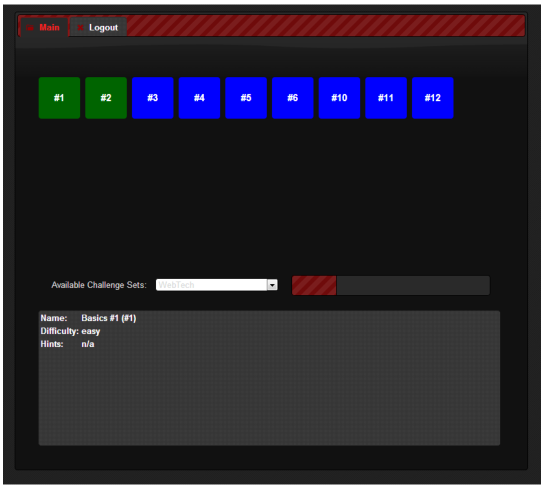
[1] https://www.owasp.org/index.php/Category:OWASP_Top_Ten_Project

After the user sucessfully solved a challenge, which in most cases corresponds to obtaining the hidden password or gaining access to a protected area, the user is informed about this success and brought back to the challenge overview. In this overview, the just-solved challenge changes its color and thus eases the overview over the overall progress (see Figure 2).



Available Challenge Sets: WebTech

Name: Basics #1 (#1)
Difficulty: easy
Hints: n/a

Figure 2: The overall progress of a certain learner.

To overcome non-self-explainatory instructions or to motivate the learner to work on a possibly less engaging exploit or vulnerability, the HackIt!-Framework wraps the challenges in a story that follows the user throughout the set and supplys him with information regarding the task.

To prevent frustration, the HackIt!-Framework will offer its users the ability to request hints by clicking on a button to point them in the right direction. These clues vary in their detailedness by starting from a very basic hint, like which subject has to be investigated, up to a detailed problem description and optional steps required to solve the challenge. In order to decrease the overuse of this optionally enabled feature, its usage can optionally cause certain penalties to the user. These penalties can range from a simple subtraction of points, the use of a modifying factor to the amounts of points the challenge normally would yield, up to the marking of the user's challenge as "solved with hints".

Since an important point of human psychology is motivation, the HackIt!-Framework allows users to compete against each other by providing a public scoreboard, on which they are able to see each other's progress. The position on this scoreboard is determined by the amount of challenges solved, their difficulty, and optionally the time required to solve it.

3.2 Setup and Usage

To ensure the security of the host system as well as an easy deployment of the HackIt!-Framework, it will be distributed as an almost ready-to-use virtual sandbox image for the virtualization software VirtualBox.

The framework itself can and should be hosted by the teacher. It provides a Web server which is capable of handling all the requests. There is no need for the students to install anything on their PCs. The challenges can (mostly) be solved by only using a web browser. Since this is a centralized client-server system, the administrator (the teacher) is able to assemble to challenges and to view the results.

4 RELATED LEARNING ENVIRONMENTS

Aside the HackIt!-Framework, there is the project HackThisSite[2], which also provides HackIt challenges to its users. This website offers tasks in different categories: basic, realistic, application, programming, phonephreaking, extbasic, JavaScript, steganography and IRC missions. Only the Basic, JavaScript, and Realistic challenges are comparable to the HackIt!-Framework. The other challenge types specialize on finding hidden messages inside images (steganography), abusing known Internet Relay Chat (IRC) vulnerabilities, writing programs to solve certain tasks within a short time limit which require decent times for humans (Programming) or reverse engineering programs to make them reveal their secret (Application). As these challenge types do not sensibilize the user to (Web) security, but rather in more advanced or more specialized topics, these kinds of challenges are currently not included in the HackIt!-Framework. But due to the fact that the HackIt!-Framework is completely modularized, these types of challenges could be easily created and added later on, as there is no restriction in the kind of challenge that the framework supports.

A different example is the website Happy-Security[3] which also offers various kinds of challenges: exploits, Flash, IRC, Java, JavaScript, cryptography, logic, programming, reverse engineering, steganography and PHP. The challenges of the different categories vary in their difficulty and can be created by the participants themselves. Most of the categories are outside of the scope of the HackIt!-Framework but especially the basic challenges, like

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[2] http://www.hackthissite.org

[3] http://www.happy-security.de

the in the JavaScript or the exploit category, are compareble to those of the proposed framework. Still Happy-Security is difficult to use for educational purposes as it does not allow customization for courses of different difficulties or feedback on the learning progress for the tutor.

A possible drawback of the HackIt!-Framework in comparision to these websites is the community. In their forums, users are able to ask questions regarding the challenges, and others try to point them in the right direction without spoiling too much information. This kind of community feedback is replaced with the upcoming hint system in our framework.

The benefit of the HackIt!-Framework is its modularized core, allowing easily exchangeable challenge sets, user management as well as an easy inclusion of own and new challenges. This allows a quick growth without much effort, as most functionality is provided by the framework. Besides, the related systems do not offer the possibility to view or export the results of the (un-)solved challenges of the students.

5 CONCLUSIONS

This paper presents the development and features of the HackIt!-Framework, a Web-based framework for modular challenge set creation. It provides a solid base for further computer security learning content and enables to teach the security aspects of current website security as well as today's Internet risks.

The focus on modularity should ensure a flexible and persistence use, whereas the strong self-security measures allow a save deployment in educational settings. The possibility to adopt its challenges to the target audience's knowledge level make it a suitable choice for weekly exercises or smaller competitions.

5.1 Future Work

There are many ways to extend the HackIt!-Framework and enrich its features. The implemented challenges for this system do not cover the complete set of the main security issues. The next steps are to implement several ideas for challenges to have a good basis that covers most of nowadays security problems and to keep the framework and its content always interesting and feature rich.

The HackIt!-Framework is work in progress. Some described features are not deployed or fully tested at the current time. These are namely the scoreboard, the hint system, the story, the unique passwords, the flagging challenges as optional or required, and the order enforcement of challenges. The deployment and the testing of these features will be done in the near future to have the system fully functioning for the upcoming evaluation.

The authors plan to use the HackIt!-Framework as a method to teach students of a Web Technologies lecture how easy it can be to exploit self-implemented Web applications if the source code is not sanitized well. In this evaluation, not only the interface design and the ease of use will be evaluated but also if the students will be aware of the risks of implementing Web application when it comes to security issues. Last, but not least, it should be determined if the students like to play with those challenges and if it is easier for them to learn about possible counter measurements by solving quests instead of learning about those threads in a theoretical way.

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Detection of Inconsistencies in Student Evaluations

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Keywords: Grading, Student Assessment, Inconsistent Evaluation, Textual Evaluation, Personalization.

Abstract: Evaluation of the solutions for the tasks or projects solved by students is a complex process driven mainly by the subjective evaluation criteria of a given teacher. Each teacher is somehow biased meaning how strict she is in assessing grades to solutions. Besides the teacher's bias there are also some other factors contributing to grading, for example, teachers can make mistakes, the grading scale is too rough-grained or too fine-grained, etc. Grades are often provided together with teacher's textual evaluations which are considered to be more expressive as a single number. Such textual evaluations, however, should be consistent with grades, meaning that if two solutions have very similar textual evaluations their grades should be also very similar. Though, some inconsistencies between textual evaluations and grades provided by the teacher used to arise, especially, when a teacher has to assess a large number of solutions, or if more than one teacher is involved in the evaluation process. We propose a simple approach for detection of inconsistencies between textual evaluations and grades in this paper. Experiments are provided on two real-world datasets collected from the teaching process at our university.

1 INTRODUCTION

The way how a teacher grades students' tasks or projects is a complex process depending on the teacher's *subjective evaluation* criteria. However, teachers are usually not provided with standards for grading, only some district or school policies offer some guidance for teachers (Banta et al., 2009; Walvoord and Anderson, 2009). Moreover, in many cases, an evaluation has to be done on a fine-grained scale (e.g. from 0 to 100) facilitating a teacher to grade two very similar or even equal solutions slightly differently. On the other hand, a roughly grained grading scale (e.g. from 1 to 5) often forces the teacher to under-evaluate or over-evaluate student works because the grading scale does not allow her to give a rating in between some certain two values. What difference does it really make if the grade is 2- or 3+ instead of 2 or 3, respectively (Carell and West, 2010)? Evaluation is a highly inconsistent process. Teachers have various types of evaluation and assessment criteria they give different values to and weight them differently (Suskie, 2009; Rockoff and Speroni, 2010).

Grading also tends to reduce students interest in the learning itself. Students tend to lose interest in whatever they have to do, instead they are rather focused to get a grade (Kohn, 1999). Results of some research demonstrated that "grade orientation" and "learning orientation" are inversely related, and that grading also tends to reduce students preferences for challenging tasks what affects the quality of students thinking (Beck et al., 1991; Milton et al., 1986; Milton, 2009).

In many cases, grading are provided together with a *textual evaluation*, a kind of a review, i.e. teacher's comments or complains to solutions. We think that a textual comment represents a more precise and expressive evaluation as a single number (a grade) because the teacher has the ability to express her attitude to the given solution in a more detailed view. However, textual evaluation is basically considered just as a feedback for the students and as a justification for the grading. In official reports, the final mark is used, though.

There is one important issue which should be taken into account here, namely, that textual evaluations should be consistent with the grades. It means that if the teacher provides very similar reviews for two solutions, the corresponding grades should be also very similar. This is especially important when there are more teachers evaluating students' solutions for the same lecture/topic since each teacher is somehow *biased*, i.e. some of them evaluate very strictly, some of them are more friendly, etc. The problem of biases is well-known in recommender systems, especially in rating prediction (Koren et al., 2009). Real data shows[1] that there is a variance in rating biases w.r.t. the opinions expressed in product reviews even in case of a single user. i.e. a user overrates some items relative to the opinions/sentiments provided in her textual reviews for these items, while in the case of other items it is the opposite.

We were motivated in this work by a *real example* from one course at our university. The "Programming, Algorithms and Complexity" lecture is provided by one lecturer, however, the tutorials are realized by five assistants, each of them leading one group[2] of about 15-20 students. It is important that there are no two solutions with the same or very similar textual evaluations but quite different grades.

This work focuses on finding such inconsistencies in teachers' gradings according to their textual evaluations. The resulting set of inconsistent grade assessments can then be used to unify the evaluation process within a large course taught by more teachers, or in cases when one teacher has to evaluate a large number of solutions. The contributions of this work are the following:

- We introduce a formal model for the problem of inconsistency detection in teachers' evaluations. To the best of our knowledge, this work is the first one devoted to this problem.
- We propose a simple approach to detect inconsistent evaluations utilizing TF-IDF, a well-known techniques from information retrieval. We illustrate the complete process of inconsistency detection on two real-world datasets, both collected from our colleagues at our university.

2 INCONSISTENT EVALUATIONS

In our formal model, we define a *task* as a triple $\mathbf{t} = (\sigma, \pi, \varsigma)$, where σ, π and ς refer to student, problem to be solved, and, the the provided solution for the given problem by the given student, respectively.

Teacher's *evaluation* is represented as a quadruple $\mathbf{e} = (\tau, \mathbf{t}, \theta, \gamma)$ where τ refers to teacher, $\mathbf{t}$ refers to task as defined above, and, θ, γ refer to the textual evaluation and grade, respectively, assigned by the given teacher to the given task. The textual evaluation $\theta = (w_1, w_2, \dots, w_k)$ is basically a sequence of words (terms) in the same order as they appear in the text, while $\gamma \in \mathbb{Q}$ is some rational[3] number. From now on, we will call textual evaluations as reviews.

Information collected about the concrete entities of σ, π, ς or τ are not necessary for inconsistency detection (see the proposed approach below), however, it is good to have these information captured in our model to be able to derive some additional facts, such as, which teachers are the highest inconsistency among, which problems to be solved cause high inconsistencies between evaluators, etc.

The set of evaluations, the input for our inconsistency detection approach introduced here, is denoted as $\mathcal{E} = \{\mathbf{e}_1, \dots, \mathbf{e}_n\}$.

The set $\mathcal{I}$ of inconsistent evaluations contains those pairs of evaluations for which the textual parts (the reviews) are similar but the grades differ.

$$\mathcal{I} = \{(\mathbf{e}_i, \mathbf{e}_j) \mid sim(\theta_i, \theta_j) \geq \delta,\ dif(\gamma_i, \gamma_j) \geq \varepsilon\} \quad (1)$$

where $sim(\theta_i, \theta_j)$ is a similarity of the reviews $\theta_i \in \mathbf{e}_i$ and $\theta_j \in \mathbf{e}_j$, and $dif(\gamma_i, \gamma_j)$ denotes the difference in grades $\gamma_i \in \mathbf{e}_i$ and $\gamma_j \in \mathbf{e}_j$.

2.1 Similarity of Textual Evaluations

In order to compute the similarity of reviews, first we need to represent these reviews in an appropriate way. For this purpose we use the *TF-IDF* function (Spärck Jones, 1972; Robertson, 2004; Wu et al., 2008) that stands for *term frequency–inverse document frequency*. TF-IDF is often used in information retrieval and text mining (Ramos, 2003) for measuring how important a word is related to a review in a collection of reviews. TF-IDF is the product of two statistics, term frequency and inverse document frequency.

In the case of term frequency $TF(w, \theta)$ is simply defined as the proportion of the raw frequency of the term w in the review θ and the maximal frequency of any term w' in the review θ:

$$\mathrm{TF}(w, \theta) = \frac{freq(w, \theta)}{max\{freq(w', \theta) \mid w' \in \theta\}} \quad (2)$$

The inverse document frequency is a measure of whether the term w is common across all the reviews and is defined as the ratio of the number of all reviews to the number of reviews containing the term w:

$$\mathrm{IDF}(w, \mathcal{E}^{\theta}) = \frac{|\mathcal{E}^{\theta}|}{|\{\theta' \in \mathcal{E}^{\theta} \mid w \in \theta'\}|} \quad (3)$$

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[1] E.g. Amazon Product Review Data (Jindal and Liu., 2008), `http://liu.cs.uic.edu/download/data/`

[2] Student groups are organized according to the capacities of computer rooms and the programming skills of students.

[3] Grades are often representing percentages or some ratios of acquired points related to the maximum number of points. Thus, it is natural to consider rational numbers.

where $\mathcal{E}^{\theta} = \{\theta_i \mid \theta_i \in \mathbf{e}_i, \mathbf{e}_i \in \mathcal{E}\}$ is the set of (textual) reviews appearing in the evaluations in $\mathcal{E}$.

Each review $\theta \in \mathcal{E}^{\theta}$ is represented as a m-dimensional vector of TF-IDF scores $\theta^{\text{TF-IDF}} = (\text{TF-IDF}(w'_1, \theta, \mathcal{E}^{\theta}), \ldots \text{TF-IDF}(w'_m, \theta, \mathcal{E}^{\theta}))$, where $w'_1, \ldots, w'_m \in \mathcal{W} = \{w' \in \theta \mid \theta \in \mathcal{E}^{\theta}\}$ are all the terms appearing in all the reviews, and the TF-IDF score is calculated as:

$$\text{TF-IDF}(w, \theta, \mathcal{E}^{\theta}) = \text{TF}(w, \theta)\,.\,\text{IDF}(w, \mathcal{E}^{\theta}) \qquad (4)$$

Since, each review θ is represented as a m-dimensional vector $\theta^{\text{TF-IDF}}$, we define the similarity of two reviews θ_i, θ_j as their *cosine similarity* (Tan et al., 2005), a well-known vector similarity measure

$$sim(\theta_i, \theta_j) = \frac{\sum\limits_{l=1}^{m} \theta_{i_l}^{\text{TF-IDF}} \theta_{j_l}^{\text{TF-IDF}}}{\sqrt{\sum\limits_{l=1}^{m} \theta_{i_l}^{\text{TF-IDF}^2}} \sqrt{\sum\limits_{l=1}^{m} \theta_{j_l}^{\text{TF-IDF}^2}}} \qquad (5)$$

2.2 Difference of Grades

When computing the difference between two grades γ_i and γ_j, we have to take into account also the size of the grading scale which is an interval $[\gamma_{min}, \gamma_{max}] \subset \mathbb{Q}$ of grades with $\gamma_{min}, \gamma_{max}$ being the minimal and maximal possible grades, respectively. The difference of two grades γ_i and $\gamma_j \in [\gamma_{min}, \gamma_{max}]$ is computed as

$$dif(\gamma_i, \gamma_j) = \frac{|\gamma_i - \gamma_j|}{\gamma_{max} - \gamma_{min}} \qquad (6)$$

2.3 Inconsistency Detection

Before introducing the algorithm, similarly to $\mathcal{E}^{\theta}$, we define the set $\mathcal{E}^{\gamma} = \{\gamma_i \mid \gamma_i \in \mathbf{e}_i, \mathbf{e}_i \in \mathcal{E}\}$ of grades appearing in the evaluations in $\mathcal{E}$. The above defined set $\mathcal{I}$ of inconsistent evaluations can be computed by the following algorithm:

Algorithm 1: Inconsistency detection.

```
Input: $\mathcal{E}, \mathcal{E}^{\theta}, \mathcal{E}^{\gamma}, \varepsilon, \delta$
Output: $\mathcal{I}$

  for $i = 1$ to $n - 1$ do
    for $j = i + 1$ to $n$ do
      $sim_{reviews} \leftarrow sim(\theta_i, \theta_j),\ \theta_i, \theta_j \in \mathcal{E}^{\theta}$
      $dif_{grades} \leftarrow dif(\gamma_i, \gamma_j),\ \gamma_i, \gamma_j \in \mathcal{E}^{\gamma}$
      if $sim_{reviews} \geq \varepsilon$ and $dif_{grades} \geq \delta$ then
        $\mathcal{I} \leftarrow \mathcal{I} \cup \{(\mathbf{e}_i, \mathbf{e}_j)\}$
      end if
    end for
  end for
  return $\mathcal{I}$
```

3 EXPERIMENTS

We have used two real-world datasets, the first labeled "PAC"[4] and the second labeled "PALMA"[5]. Both datasets contain the following information about evaluations: *studentID, taskID, teacherID, grade, review*. For our experiments, however, we used only the following tuples: $(ID, grade, review)$, where ID is a unique identifier created from $studentID$, $taskID$ and $teacherID$. The main characteristics of the datasets are described in table 1.

Table 1: Characteristics of the datasets used.

Dataset	#Students	#Tasks	#Instances
PAC	82	18	174
PALMA	141	154	1501

First, we computed similarity of reviews using the TF-IDF measure as defined in the equation (4). This technique has also filtered "unusable" and "rarely used" words in reviews which we could omit from the consideration making the computation faster. In the next step we computed the set of inconsistent pairs of evaluations according to the algorithm 1.

The results shown in figures 1 and 2 refer to the number of inconsistent evaluations found in the data for different ε and δ. Since the PAC dataset is smaller, naturally we have found less inconsistencies than in the case of the PALMA dataset in which there are 8 pairs of evaluations ($|\mathcal{I}| = 8$) where the evaluated tasks are the same and the textual reviews for these tasks are equal ($\varepsilon = 1$) but their numerical evaluations (grades) differ with more than 30% ($\delta = 0.3$).

ε	δ	$\|\mathcal{I}\|$
1	0.05	0
1	0.1	0
1	0.3	0
0.95	0.05	4
0.95	0.1	4
0.95	0.3	1

ε	δ	$\|\mathcal{I}\|$
0.90	0.05	4
0.90	0.1	3
0.90	0.3	1
0.85	0.05	18
0.85	0.1	16
0.85	0.3	6

Figure 1: Results for inconsistency detection for various ε and δ in the PAC dataset.

The choice of the concrete values for δ and ε for our algorithm depends on the individual requirements

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[4] Collected from the "Programming Algorithms Complexity" course at the Institute of Computer Science at Pavol Jozef Šafárik University during the years 2010–2012.

[5] Collected from the "PALMA junior" programming competition organized by the Institute of Computer Science at Pavol Jozef Šafárik University during the years 2005–2012.

ε	δ	$\|I\|$
1	0.05	8
1	0.1	8
1	0.3	8
0.95	0.05	13
0.95	0.1	11
0.95	0.3	9

ε	δ	$\|I\|$
0.90	0.05	13
0.90	0.1	10
0.90	0.3	8
0.85	0.05	14
0.85	0.1	12
0.85	0.3	7

Figure 2: Results for inconsistency detection for various ε and δ in the PALMA dataset.

of lecturers. However, providing results for different combinations of values of δ and ε (as in the figures 1 and 2) allows the teachers to gain better insight to the evaluation process of their lectures.

4 CONCLUSIONS

Teachers should evaluate students' solutions consistently, however, this is not always the case. We proposed a simple and easy to implement solution for detecting inconsistencies in the evaluation process when the textual review of two solutions provided for the same task are very similar but the numerical grades differ. Since, to the best of our knowledge, our work is the first dealing with this issue, we also introduced a formal model of the inconsistency detection problem. Experiments on two real-world datasets show that even in a small scale we can found inconsistent evaluations.

We provided our findings to the colleagues who provided us with the datasets as well as to some of our other colleagues at our university. Positive feedbacks from these teachers show that the introduced approach for evaluation inconsistency detection is helpful in the teaching process and worth further investigation.

Our further research will focus on the relationship between assessment methods and the learning outcomes of students, as well as the investigation of utilizing different feature extraction methods (Petz et al., 2012; Holzinger et al., 2012) in our approach.

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Online Materials for Practicing and Evaluating Statistics Knowledge
e-Learning Formative Evaluation in Computer Practices

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Keywords: Guided Practices, Online Evaluation Tools, Statistics Software.

Abstract: Auto-learning and self-evaluation are two main topics in ECTS environments. In this framework, new technologies are widely used to develop online tools which provide students the possibility of practicing and evaluating their learning progress. With this idea, guided practical for the application of the basic statistical techniques on a computer and self-evaluation tests have been developed for students of Physiotherapy Degree within a Learning Innovation Project supported by the University of Jaén (Spain). This paper reports our experience in the implementation of this learning material and evaluation practice in the teaching-learning process during the last academic year.

1 INTRODUCTION

From the development of the European Higher Education Area (EHEA), a new university learning system has arisen where new technologies are widely used in an educational model more focused on the student (see, e.g., Jolliffe et al., 2001; Martínez et al., 2010; Jiménez et al., 2011; Craig, 2012). In this model, the teaching-learning process is the heart of education, where the teacher, the leaner, the curriculum, among other variables, are organized in a systematic way to attain predetermined goals and objectives (Bissa and Sharma, 2010).

Information and Communication Technologies (ICTs) constitute an unbeatable tool to prepare students in the use of statistical knowledge for the analysis, diagnosis and resolution of problems. In fact, a great effort has been made to elaborate learning materials which support the teaching presence and make the learning process more attractive to students. In this framework, the auto-learning and self-evaluation are two main topics in ECTS environments that motivate to develop novel tools that help students in their teaching-learning process (see, for example, Caballero et al., 2005; Olmo et al., 2009; or Jiménez et al., 2011, among others).

On the other hand, Statistical Software obviously is a computer tool less commonly used by people but very useful to process statistical data. In fact, the use of this type of software allows the practical application of the techniques exposed in the theoretical lessons and prepares students to their future professional activity (Godino, 1995).

For these practices on computer, it is really useful for students to have support materials helpful in their teaching-learning process.

With this idea, and within a Learning Innovation Project that is being developed in the Physiotherapy Degree of the University of Jaén in Spain, we propose guided practical to solve questions related to those statistical techniques that have been studied in master classes, hence they practice with the contents of the subject avoiding calculus and focusing on interpretations of results.

Moreover, an important part of guided practices is "checking for understanding". Different researches on formative assessment and feedback have shown how these processes can help students in their own learning. For that, it is necessary that teachers organise assessments and support learning which promote an active rather a passive role of the student in this task. Examples of evaluation systems encouraging the automatic feedback can be found in the literature (Wang, 2012); (Queiros and Leal 2012); (Nicol and Macfarlane-Dick, 2006)

In this framework, self-evaluation tests allow the student to check how the learning procedure is carrying out. This provides a feedback for students because, once they have finished the test, they can see the obtained score and the correct solution for each question. The objective is to provide students of Physiotherapy Degree an opportunity to develop and improve their knowledge on this subject by using it.

The experience was to create a bank of questions to elaborate follow up questionnaires and evaluation tests for each lesson, so the student knows the degree of achievement of the course objectives and it suppose a feedback on the learning process.

In addition, the teaching process is evaluated and it is improved, from the students answer to items regarding a proposed survey. The results of the poll came out the utility of the software, the adequacy of the questions to the contents, the advantage of feedback to correct conceptual, procedure or interpretation errors. The students were grateful for practical problems related to their field.

This positive belief on the project motivates us to continue looking for real data mainly on health sciences and to incorporate new questions to our banks to enrich them and to bring statistic tools closer to our students; demystifying topics over them and showing that it is a useful science rounding us that must be known and properly applied.

2 WORK DESCRIPTION

Although the use of computer tools is widely extended nowdays, the practices on computer in the Statistic subject of the Physiotherapy Degree suppose a challenge for students since, in general, this is their first experience with statistical software.

Then, as it has been indicated above, the objective of our Learning Innovation Project was to elaborate guided practical besides bank of questions to be used in tests for evaluating the computer practices with Statgraphics in this subject. And, for this purpose, the ILIAS Virtual Learning Platform gives a suitable environment to develop these materials which can be used by students in any moment and place.

On the one hand, guided practices pretend showing and releasing the students to solve practical cases at hand by using the theoretical statistical concepts studied in the subject and using statistical software. The idea is to model the way a problem comes to a solution. On the other hand, evaluation and self-evaluation tests allow the students to assess their own performance while they have the opportunity to obtain feedback from their own answers.

Computer practices for the subject “Statistic” of the Physiotherapy Degree are structured in six sessions of about 2.5 hours each:

Session 1. Introduction to the use of Statgraphics
Session 2. Descriptive analysis of data
Session 3. Probability distributions
Session 4. Parametric statistical inference on one variable
Session 5. Parametric statistical inference on two variables
Session 6. The linear regression model

So, one guided practical, a bank of questions and a self evaluation test have been created for every practice session.

The methodology followed in this project can be summarized in the following steps:

1. **Collection of Materials.**
   An exhaustive search and selection of materials related to the resolution of statistic problems in the Health Sciences field has been carried out.
   Moreover, during the first weeks of the semester, students filled out a survey prepared on purpose to get real data of different variables in the Physiotherapy field.
2. **Design of Guided Practices.**
   One guided practice has been created for every practice session, with the aim of showing students the best way of solving different type of exercises by the application of the theoretical concepts studied in this part of the subject.
3. **Elaboration of Banks of Questions in ILIAS.**
   For every practice session, a bank of questions has been created in the ILIAS Virtual Learning Platform with the answers to the exercises proposed in this practice. ILIAS platform has allowed us the use of different types of questions: multiple choice, numeric response, ordering, fill-in-the-blank, short answer or matching questions, among others.
4. **Layout of Self-evaluation Tests in ILIAS.**
   From the above banks of questions, different self-evaluation tests have been performed including the different types of questions allowed by the ILIAS platform. The main aim of these tests is that students can self-evaluate the suitability of their results in the computer practices.
   These tests provide a feedback for students because, once they have finished the test, they can see the score obtained and the correct solution for each question. Moreover, students can repeat every test in any moment until they get the desirable result.
   Finally, an evaluation test, similar to the self-evaluation tests given for every computersession, was used in the final computer practices exam.

3 ANALYSIS OF RESULTS AND CONCLUSIONS

The aim of this section is to show our experience in the use of these materials in the subject "Statistics" of the Physiotherapy Degree during the last academic year 2011-2012.

During this academic year, the above described materials were used to evaluate the part of the assessment system corresponding to computer practices which supposes a 30% of the final mark of the student. With this methodology, the 70% of students joined in the subject "Statistics" passed the practices evaluation with a good mark. Unfortunately, there is not any historical data for comparison but it can be considered a satisfactory percentage, taking into account the difficulty that Statistical issues suppose for these students.

Furthermore, to evaluate the elaborated materials and their utility in the evaluation process, students were proposed to respond a survey created in the ILIAS platform with question related to the computer practices and their evaluation.

This survey was initially proposed to all students joined to this course, i.e., over a whole of 81 students, but it was voluntarily filled out by 47 of them. This fact supposes a participation percentage of about 50.6%.

The items of this survey were structured in three blocks related to:

1. the computer practices
2. the self-evaluation tests
3. the evaluation test for the computer practices exam

Students might value each item with a mark from 1 (completely disagree) to 4 (completely agree).

The best valued items, with modal value of 4, were:

- Computer practices fit with the theory.
- The used software is accessible, user-friendly, work environment, etc.
- Computer practices have helped me to understand the statistical concepts.
- The questions in self-evaluation tests are appropriated for the computer practice developed.
- The type of test is easy and comfortable to use from the ILIAS platform
- Questions in the evaluation test are adapted to the computer practices solved during the sessions and the self-evaluation tests.

On the other hand, the worst valued items, with a modal value of 2 were two specific questions:

- Clarity of some questions and lack of ambiguity.
- Data used in computer practices are of interest in the Physiotherapy field.

With respect to the first of these items we must say that although this answer can be motivated by the formulation of questions which motivate the statistical reasoning, we think that they should be revised in order to avoid any confusion.

On the other hand, the second issue highlights that the exhaustive seeking of examples in the Health Sciences environment has been insufficient and unsatisfactory for the interests of our students and a major effort should be done in this sense.

From students' opinion, our general evaluation of this experience is very positive. Moreover, we would like to emphasize the generality of the learning material presented here which can be used as a learning support in many other compatible subjects with basic statistics contents.

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A Web-based Support System for Providing Effective Monitoring, Feedback and Evaluation in Project Management Education

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Keywords: Project Management, Distant Learning, Collaborative Learning, Web 2.0.

Abstract: This work introduces a web-based learning environment to facilitate learning in Project Management. The proposed web-based support system integrates methodological procedures and information systems, allowing to promote learning among geographically-dispersed students. Thus, students who are enrolled in different universities at different locations and attend their own project management courses, share a virtual experience in executing and managing projects. Specific support systems were used or developed to automatically collect information about student activities, making it possible to monitor the progress made on learning and assess learning performance as established in the defined rubric.

1 INTRODUCTION

Project Management education was traditionally designed according to an expository paradigm that was accompanied by exercises to directly apply a particular technique or use a specific tool. However, exercises or case studies do not provide sufficient stimuli to foster the level of engagement needed to effectively facilitate learning (Barron, 2005). The teaching and learning of project management has grown in interest and popularity recently ((Berggren and Sderlund, 2008), (Ojiako et al., 2011)) and it is well accepted that new and non-traditional initiatives are required. It is important to ensure that students move into a higher order of thinking and learning with the idea of moving from knowing what to know to knowing how and why to know (Roger, 2008).

In the process of acquiring the competences required to become project management professionals, learners seek to acquire a learning process that provides them with experiences that are similar to what they will encounter in the world beyond the classroom. The ability to work in teams and to communicate effectively is deemed to be an essential skill. This is particularly important when design team members are based in differing locations and meet in a virtual environment (Rooij, 2009).

This paper introduces a new web-based learning environment that is designed specifically to facilitate a structured approach to involve M.Sc. students in project management and B.Sc. students in project engineering learning processes.

Section 2 presents a brief review on related works. Section 3 provides an overview of the learning experience and section 4 is dedicated to describe the web-based support system designed. Finally, the last section discusses some general conclusions and presents future work.

2 BACKGROUND

There is evidence that teaching Project Management must be organized in a more learner-centered approach than classical lectures offer. Several practical approaches to the teaching of project management can be found in the literature.

For instance, (Martin, 2000) presents a software environment for generating customized computer-based simulations that facilitate project management education. (Abernethy et al., 2007) describe a specific experimental approach for information technology students. They argue that project activities must mirror the real world, if information technology students are to learn what needs to be done in industry projects. (Cobo-Benita et al., 2010) proposed a teaching approach that is based on the learning by doing paradigm to enable students to acquire technical knowledge and to develop some human skills, such as conflict resolution, complex problem-solving and decision making.

More recently, (Crespo et al., 2011) advocated a combination of theoretical content, individual applied tasks, use of software systems and a strategy of learning by doing in teaching project management. They formally introduce negotiating and virtual team management aspects to different teams from different universities in different locations.

(Mawdesley et al., 2011) focuses on a teaching module that employs simulation games as the primary source of instruction in a self-directed learning exercise. Similar approach has been reported by (Ordieres-Meré et al., 2011) where the gap reductions between academia and the industry were discussed.

According to the previous non exhaustive overview there are so many already proposed framework that it is relevant to make clear why one more framework is required. Authors believe that there is not a convenient framework allowing to foster the project management learning process from an structured point of view, including distant, cooperative learning and based on evidences and paying attention to learner's competence development.

3 COURSE DESCRIPTION

The learning experience presented is based on *playing to manage projects*. The main purpose is to move on from simply learning content by heart to understanding, discussing and sharing in order to learn from experience.

To reinforce concepts and improve learning by traditional methods, the simulated scenario involves the student in the development of a real engineering project. Thus, the instructors team adopts the role of a corporation that has decided to embark on the construction of a new facility in accordance with its feasibility studies.

In this study, the program owner, P2ML INC., wants to invest in the rising up automotive oriented nano-coating market. As a part of its strategic plan, this corporation is considering hiring a company as provider of basic engineering services for its new plant. Main representative for the owner into the project board will be the teachers.

The companies in the program are composed of students from two different universities, Universidad Politcnica de Madrid (UPM) and Universidad de La Rioja (UR). P2ML INC. expects to obtain the technical documentation necessary to authorize and build the facility. This includes both documents and digital content like computer models and systems.

It is expected that students will learn and apply a methodology that enables them to manage projects better. As a way to develop their own strategy, they will learn the project management method (Project in Controlled Environments: PRINCE2 ^{TM}). This method is published by The Stationery Office (TSO), is protected by Crown copyright, and is owned by the Cabinet Office of the UK Government Commerce (OGC) (Office Of Government Commerce, 2009). The use of this method, even for academic purposes is not new, as it has been frequently reported ((Hewagamage and Hewagamage, 2011) and (Zhang et al., 2012)).

According to the chosen method a multiphase lifecycle is accomplished, where meaning for all of them is learnt during the first three weeks of the course. The general picture of the project life-cycle can be seen at Figure 1.

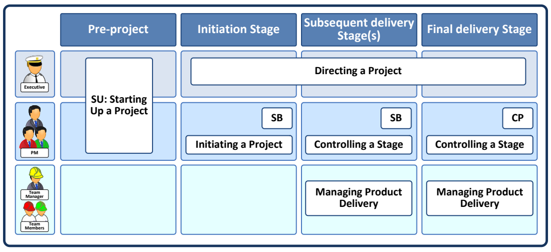

Figure 1: Project life-cycle: phases and processes.

Although the two main roles, teacher and student, are still recognizable, they have evolved. Teachers still have the traditional roles of evaluator and knowledge provider, but now must also assume the following roles:

- **Owner.** To identify his or her interests and to negotiate various aspects to ensure that her interests are carried out.
- **Auditor.** To be responsible for the independent assessment of specific aspects of the evaluation indicators and also for any corrective action, if necessary.

For the students learning process, it is necessary to make clear the difference between the different roles of persons who work together on the same project, but with very different responsibilities. In order to do this, and because students from different locations and different backgrounds are involved, they are exposed to different participation experiences by playing three different roles:

- **PM.** Project Manager, with management responsibilities. Each project is managed by a team of seven or eight PM.

- **TMg.** Team manager. A PM temporarily assigned to manage Project Engineers (TM), to produce what it was described into the Work Package document (Managing Products processes).
- **TM.** Team member, with engineering tasks development responsibilities. Each project is composed of seven or eight TM.

In order to promote cross learning process each learner is requested to invest forty working-hours as PM and thirty working-hours as TM.

4 SYSTEM ARCHITECTURE

To facilitate the development of the learning experience, a set of information systems are used. The designed support system is a web solution based on the following software tools (Figure 2):

- An Enterprise Program Management Office (ePMO) that provides the necessary project management tools, as well as some collaborative tools such as blogs, forums, news, automatic e-mail reports, document repository, etc.
  The selected ePMO software was Project.net (http://www.project.net), which is a well known Project and Portfolio Management (PPM) software. This software facilitates the students use of the different roles that coexist in the management of a project, enabling the team members to communicate and work together even though they may be located at distant locations.
- A 360-degree feedback web that contains the designed surveys for collecting numerical assessments about each of the project members regarding their behavioural skills, as well as their teamworking orientation. This makes possible for learners not only become focused on the technical aspects of the assigned work, but also pay attention to other social skills which are keystone for professional PM.
  The designed forms were generated by means of Limesurvey® (http://www.limesurvey.org), an open source, PHP-based web application that allows to develop and publish online multi-question multi-lingual surveys. Moreover, jQuery applications were developed to communicate the survey engine with the ePMO software in order to customize the surveys at runtime by authenticating the user, automatically providing individual information once the user has been authenticated (projects, role, actual phase,...), etc.
- An integration tool (P2ML) specifically developed to monitor the operation of the simulation for each participant, to provide forensic traceability to the assessments, to provide feedback about the learning progress of each participant, and to integrate the data collected from the previous tools to obtain a performance assessment of each participant.
- A global forum to deal with methodological issues. Learners used to ask colleagues and sometimes the same question find different answers. In order to make it possible to increase the *social knowledge* this maintained resource was provided.
- A course management system (CMS), used to deliver pieces of knowledge, like lessons, tests, etc., as well as to discuss theoretical issues.
  Moodle$^{\text{TM}}$(https://moodle.org/) was chosen because it is a free web application which provides many tools to create effective online learning sites.

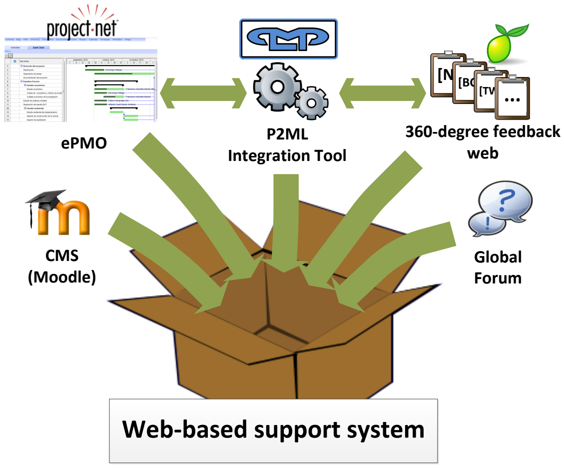

Figure 2: Collection of web tools used and created for the designed support system.

4.1 The P2ML Tool

In order to support teachers in their supervision and evaluation activities, a new software tool was developed by means of CakePHP (http://cakephp.org). It was designed to communicate with the ePMO software –as well as the 360-degree feedback web– in order to collect real-time information about project and team members progress, to monitor the operation of the simulation for each participant, to provide forensic traceability to the assessments, to provide feedback about the learning progress of each participant automatically, and to integrate the data collected from the previous tools to obtain a performance assessment of each participant.

This application allows instructors to make periodic reports to better identify mistakes or inappropriate behaviors. In this way, the teachers can more objectively and efficiently monitor and evaluate students continuously throughout the whole course. Furthermore, to make the most of the information gathered, the system was built to provide feedback to students automatically. It checks different analytical errors, such as links between deliverables and tasks, the relationship between tasks in the project work plan and many other problems. Thus, when a measurable mistake is identified, an e-mail is sent to all students (PM or TM) and instructors who are involved.

The presented virtual learning environment stores a huge number of variables, allowing to perform analysis that would be helpful to instructors in the design of adequate activities or identify better learning paths.

5 CONCLUSIONS

This paper has presented a virtual environment that permits learners and teachers to play around it, making possible to learn Project Management techniques. This learning environment not only include technological solutions like application servers to manage learners or gather relevant information, but also includes operating procedures that highlight methodological aspects like phases, relationships between tasks and work packages, etc.

The web-based support system is useful to promoting the Project Management learning process among geographically-dispersed students. Also, as it captures individual actions, makes it possible to verify inconsistencies in actions and can send alert messages, a type of feedback, to help learners to improve their performance, in addition to the regular assessment activities carried out by teachers.

Authors planned to use artificial intelligence techniques embedded in the support system to shed light on several matters related to learning processes, such as the differences in the learning paths that students follow.

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Building e-Learning Content Repositories to Support Content Reusability

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Keywords: e-Learning Digital Libraries, Content Reusability, SCORM, Tools for e-Learning.

Abstract: The article presents the method and tools to build repositories of digitalized didactic materials to support their reusability. The method consists of a set of recommendations for the structuring of didactic materials and of a way to assign unambiguous didactic interpretation to sections of materials by means of UCTS. SCORM and dedicated software Content Repository are among tools used for this. SCORM is a popular specification which defines principles used to represent digitalized didactic content, which allows to create reusable materials. UCTS is a taxonomic system designed to situate contents in the didactic process. Using this system to mark portions of materials ensures that users will access materials that are cohesive and relevant without the risk of downloading incomplete contents. Content Repository is a dedicated software designed to create, store and process didactic content with the ability to reuse it. A repository of teaching materials on protection and management of archaeological heritage has been created based on the method and tools discussed (E-archaeology content repository). The repository contains approximately four thousand and five hundred Learning Objects in five languages and about eight hundred units of didactically useful knowledge, which have been described in the language UCTS.

1 INTRODUCTION

A repository of didactic materials is an IT solution used to digitally store, process and retrieve didactic contents. Repositories can be made in different ways, subject to form of materials, availability of technical infrastructure, or user habits and IT skills. A solution enabling digital storage of files can be considered a repository of didactic materials. Also, a dedicated IT system which requires materials structured according to a defined specification and recorded in a selected technical standard can be considered a repository. The type of technical solution used is correlated to didactic materials and their role in the process of distance learning.

Digitalized didactic content can be incorporated in the distance teaching process in various ways depending on the methodology used. It can be used as support and supplement to the didactic process or it can serve as core source of information which replaces the teacher. Notwithstanding its role, it is essential that the teacher should be able to adapt materials to the specificity and needs of target groups. Those adapted materials can differ to a lesser or higher extent from the canonical form of the training programme. The materials modified may contain additional elements to expand certain themes, or parts of materials may be removed. For the canonical contents to be modified the teacher should have at his disposal a suitably flexible content repository. Usually, due to limited IT competences of teachers it is recommended that adaptation of contents should be done without advanced technological skills.

In order to construct flexible content repositories, it is essential for teaching materials to be constructed in such a way that they can be easily modified and repeatedly used. First of all they should have a form allowing for construction of larger structures with smaller units; also they should be saved in such a technical specification which will enable flexible processing. SCORM as well as division into Learning Objects meets this requirement. Another thing which is necessary is the mechanism of granting didactic interpretation to those sections of materials which are cohesive and useful didactically. Such sections are designed to be used in many various educational contexts, different from that in which they were initially placed. In the method presented here didactic interpretation is given by means of UCTS nomenclature (Universal Curricular Taxonomy System).

2 FORM OF DIDACTIC MATERIALS

In order to be repeatedly used, didactic materials must have adequate form. A good solution is a form of so called e-learning courses. Known as 'e-books' or 'content', they have a method of recording contents that is suited to specific features of online teaching. An e-learning course has the following characteristics:

- It contains multimedia and interactive elements which improve the attractiveness of the contents and teaching efficiency;
- It has a hierarchical structure which follows the principle of dividing contents into independent units of knowledge, so called Learning Objects;
- It is suited to be placed in any system of distance learning by the fact that is has been recorded in a standard of didactic content such as SCORM.

Multimedia and interactive elements increase the efficiency of online learning. They should always complement and expand relevant contents and not be used as mere attraction (Horton, 2006). Division of the contents into Learning Objects is an approach that relates directly to the specificity of online teaching. Students are hardly able to master the entire content of a single session of an e-learning course. Thus, if Learning Objects are divided into sections that can be mastered within three to ten minutes than the entire work becomes more effective. Complexity and large amounts of contents may cause Learning Objects to be placed in larger structures, which present selected issues and subjects. Learning Objects will be placed hierarchically in aggregating structures on several levels, depending on how detailed the content is.

The underlying feature of SCORM specification is the fact that contents can be organized in such a way that will allow for its repeated use. SCORM philosophy is based on the fact that contents are divided into numerous components and as such they are transferred into technical form such as courses, SCOs or sets of SCOs. Other technical specifications (i.e. AICC, Tin Can) may also be used. They must only allow the division of content into smaller units.

3 DETERMINING DIDACTIC USEFULNESS OF CONTENT COMPONENT

Structuring materials as Learning Objects and saving them in a flexible standard such as SCORM is a good starting point to create reusable repositories. However, such an approach does not answer the following questions:

- Which sections of materials stored in a repository are of standard didactic value?
- Which components may function on their own, i.e. are relevantly cohesive and didactically useful?
- Is it possible to incorporate fragments of contents into new structures in such a way that they are relevantly cohesive and didactically useful?

These questions in practice boil down to one: Is it possible to download any component from a repository of didactic materials, for example one SCO or several SCO, and use it in a didactic process?

For the components downloaded to be cohesive, didactically useful and devoid of purely technical character it is necessary to develop a method that will allow for interpretation of the components in the context of their didactic character. Thus, if the contents are saved in SCORM, it is not sufficient to relate to their structure because individual elements of this structure (SCO, set of SCOs, course) do not carry any information about the role of the materials in didactic process. SCORM shifts to the author the responsibility to indicate which elements of the structure are didactically useful and which have been introduced only for purely technical or organizational reasons, for example the component has been broken down into smaller units due to its volume, and in consequence individual components should not function independently.

However, to conceptualize contents so that their components may be reused many times may be a daunting task for the author. This stems from the fact that in the process of creating contents in a conventional way (e. g. while writing a book) it is not customary to consider multiple uses of its parts (chapters). It is taken for granted that the contents will be delivered to student in its totality. Therefore, in structuring contents meant for SCORM, where from a technical standpoint all methods of content structuring are possible and feasible (especially when it is regarded as a strictly technical job!) it is essential to develop and apply a more systematic approach which will enable an unambiguous determination of contents usefulness.

SCORM is neutral about the complexity of content. It does not include any curricular taxonomy model that can be used to describe the role of content in the teaching process (Dodds, 2006). Within the method presented as suitable for interpretation of didactic contents a solution is suggested that does not refer to any particular educational context – it is UCTS.

UCTS (Universal Curricular Taxonomy System) is a taxonomic model, designed to interpret didactic content (Marciniak, 2012). This model provides a description language to structure didactic materials on several levels. The model can be used to describe materials in SCORM. It can also be used to structure materials in any other form or technical specification.

UCTS provides the following components that can be used to describe didactic content:

- Curriculum,
- Learning module (or: Module)
- Learning Unit (or: Unit)

The term Curriculum is used to define contents that can be deemed as a teaching program i.e. that contains a set of materials which present a given topic in an exhaustive way, and which fulfill certain didactic goals. A Curriculum is made up of any number of Module-type components. These components are arranged in a sequence in which they should be realized by student. A Curriculum can be supplemented by an element of Exam type, which will function as a final test for the entire teaching program.

A Module can be made up of several components of Unit type, or other modules. The entire set mutually complementing each other is meant to cover a given topic in an exhaustive fashion. This component should be supplemented with an exam type element which will verify how well student has mastered the module.

A Unit is the smallest section of materials, which introduces cohesive content and which contains elements to enable students to self verify their progress. A Unit is the smallest section of contents that cannot be divided any further. This reflects the idea that for any didactic material (book, script, PowerPoint presentation) there is a certain threshold below which further sectioning of materials is not possible, although divided contents may still be relevantly valuable. It is assumed that a Unit may be made up of the following smaller elements:

- Learning Object – a section of materials which introduces new contents organized as ‘knowledge capsules’. The contents may be delivered as text, text with graphics (drawings, photographs, etc) or as multimedia and interactive content (non-linear graphs, dynamic diagrams and graphs, etc); this element may contain self verification and verification features.
- Exercise – a component designed only for self verification. This type of elements should be built in an interactive way i.e. it should contain elements of interactive testing (one-choice and multiple choice questions, drag and drop, puzzle, etc).
- Self assessment – a special type of exercise which enables students to verify their progress in a given section of contents. Questions in this component should have a cross-sectional character.
- Exam – a component to verify students’ progress. Questions in this component may be drawn at random from pools of questions, or given in a fixed set. The results should be sent to LMS/LCMS system and made available to teacher.
- References – a list of books or papers to expand on issues discussed,

4 CONTENT REPOSITORY TOOL

A Content Repository is a tool that allows for digital storage of didactic materials and for creation of new materials based on existing components (www.contentrepository.org). The tool was developed to solve the problem of electronic storage of large amounts of resources A content repository is a piece of software working in WWW environment. It is designed to create content repositories in SCORM standard (version 1.2 and 2004). It can be used to create monographic or multi-topic repositories.

A basic function of Content Repository is to create new structures of knowledge based on existing components. The system enables this in an approach that is analogous to editing, in which editor selects interesting and relevant contents. In Content Repository this activity consists of finding materials in the system and incorporating them into existing structures. This tool allows for processing only those components that have been earmarked by the author as didactically useful. This is done in the tool by ascribing a didactic interpretation to the component and by creating an artifact called Processable Unit (PU).

Processable Unit (PU) is a structure of data isolated from Content Repository, and which serves as a base on which processing of knowledge deemed by authors as didactically useful takes place. Processable Units are created by ascribing didactic interpretation to any SCORM component (Fig. 1). PU’s created in this way are defined in the system as Basic PU’s. UCTS-derived nomenclature or nomenclature derived from any other taxonomic model may be used for didactic interpretation. Content Repository is adapted to simultaneously serve numerous taxonomic models. If UCTS nomenclature is used, entitled users may ascribe one of the following values to a SCORM component (SCO, set of SCOs, course): Unit, Module, Curriculum. The system enables also creation of blank PU’s, so-called System PU’s. Their role is to aggregate other PU’s stored in the system. It is possible to embed any base PU’s or other system PU’s in system PU’s. What is important is that when a content is defined as PU, it determines whether it can be downloaded from the system. Only those content structures can be downloaded from Content Repository that have been defined as PU’s in the system.

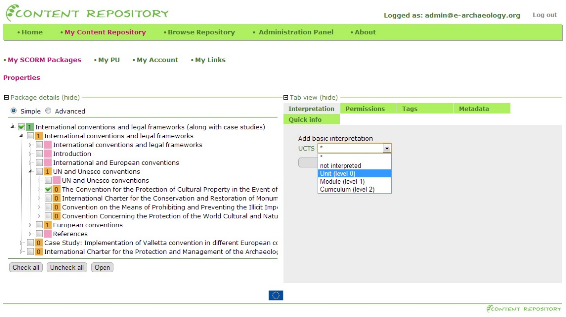


Figure 1: Ascribing didactic interpretation.

Processable Units are artifacts isolated from Content Repository which determine the level of content granularity in a repository. The system permits operations on contents only by referring to PU’s. The tool does not permit to create new content components, i.e. it is not possible to create new SCO’s nor is it possible to defragment PU’s (that is to divide into smaller units). This also means that while downloading contents from repository it is not possible to download single SCO’s isolated from the PU in which they have been embedded. So, only those content structures earmarked by the author as didactically cohesive and useful can be downloaded from Content Repository.

5 E-ARCHAEOLOGY CONTENT REPOSITORY

E-archaeology content repository is a repository of digitalized didactic contents in the area of protection and management of archaeological heritage. The repository was built using a Content Repository system. UCTS was used for didactic interpretation. The repository is available at: www.e-archaeology.org/contentrepository. The resources collected there are made up of multimedia and interactive e-learning courses.

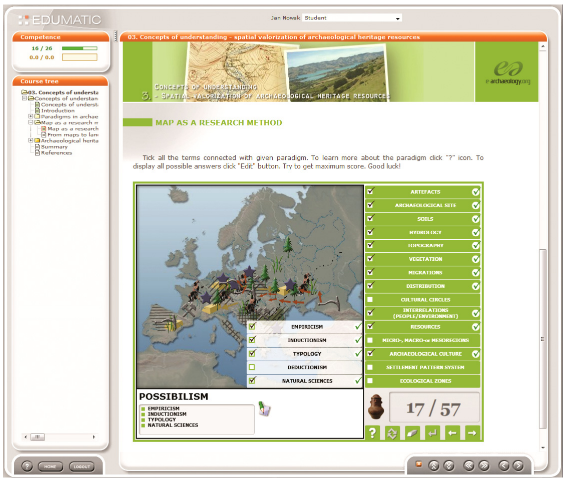
All the contents in the repository have been developed by specialists in the area of protection and management of archaeological heritage within the framework of two European Leonardo da Vinci projects. The first project, resulted in developing contents for a learning program “Protection and management of archaeological heritage in contemporary Europe”, and in building a set of e-learning courses based on this content. In the course of the second project the contents was expanded and supplemented.

Digitalized materials stored in E-archaeology content repository were built in a way suited for online teaching (Marciniak, 2009). The course components contain interactive and multimedia elements (Figure 2). Those elements introduce contents in a non-linear fashion and test students’ progress in self-tests. The structure of those materials allows their reusability. The authors divided the contents into small cohesive units of knowledge which describe topics in an exhaustive way (Kok, 2009), then these materials were digitalized in this form. While implementing the contents in SCORM (version 1.2) it was decided that individual cohesive sections of materials were saved as SCO’s. SCO’s making up individual courses are organized hierarchically, using the Activity SCORM component. These structures were selected in the course of creating the contents, thus reflecting conceptualization of the subject in accordance to author’s plan.

The repository contains didactic contents in five languages (English, German, Latvian, Polish and Spanish). There are about 4500 SCO’s, in particular (approximate values for English version):

- Fifteen training programs (curricula)
- Sixty components of Module type
- One hundred seventy-five components of Unit type
- Seven hundred SCO’s.

Authors of new learning programs and teachers using the repository content can take advantage of a range of solutions supporting search process, such as LOM metadata and tags from wordnet-based ontology in the area of protection and management of archaeological heritage used to describe the contents.



Tick all the terms connected with given paradigm. To learn more about the paradigm click "?" icon. To display all possible answers click "Edit" button. Try to get maximum score. Good luck!

Figure 2: Element of an e-learning course.

The contents in E-archaeology Contents Repository can be used to conduct a didactic process in the area of protection and management of archaeological heritage. After downloading from the repository, they can be incorporated into teaching in the following ways:

- Materials may constitute basic training programs in assisted web-base training;
- They can supplement synchronized training sessions (for example videoconferences), or conventional courses.

In order to verify the method and usefulness of Content Repository tool, in the Leonardo da Vinci project nine pilot training courses were conducted in the area of protection and management of archaeological heritage. Contents for these trainings were created with E-archaeology repository resources. The teachers running the courses created their own training programs suited to the needs of target groups. From a technical standpoint training programs are system PU's defined in Content Repository as UCTS Curricula. The teachers reused content from the repository annotated as UCTS Modules and Units while creating Curricula.

6 CONCLUSIONS

To enable creation of repositories of reusable teaching materials it is essential for the materials to have a certain form, to be didactically interpreted and to be described in such a way as to simplify search. A good solution is to save contents as SCORM and structure them as Learning Objects. It is necessary to ascribe didactic interpretation so that the repository could refer to didactic and not technical conceptualization. Use of SCORM enables division of contents in many different ways; however, not every type of division will ensure comprehensive delivery of a subject to students, nor will it ensure distance learning methodology. UCTS - compatible content conceptualization leaves room for additional didactic requirements. LOM metadata are of particular use in building SCORM contents because they allow comprehensive description of contents, and then effective repository search.

Content Repository enables creation of massive repositories of teaching materials. The system is run by SCORM and its all metadata. It permits loading e-learning courses and other types of knowledge structures, dividing them to suit the teaching needs, and building new teaching programs or other types of knowledge structures using components available. It is possible to download these components as SCORM packages. Thanks to these functionalities courses loaded into the system are not identical with what can be downloaded from it.

ACKNOWLEDGEMENTS

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Building an Intelligent Tutoring System for Chess Endgames

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Keywords: Intelligent Tutoring Systems, Artificial Intelligence, Education, Problem Solving, Chess Endgames, Chess.

Abstract: We present the development of an intelligent tutoring system for chess endgames, and explain in detail the system's architecture that is comprised of five essential components. The rule-based *domain model* contains a conceptualized domain theory, which serves as a bridge between the basic declarative domain theory and procedural knowledge for concrete problem solving. The *search engine* is used to generate new chess problems and to validate students' solutions on the fly. The *tutoring model* represents pedagogical knowledge and follows the standard model-tracing approach. The *student model* contains the knowledge about the user in the form of a skill meter, aiming to show the level of a student's understanding of particular skills. Finally, the *user interface* is where the interaction between a student and the tutor takes place.

1 INTRODUCTION

Several studies have demonstrated benefits of chess in education. Namely, the findings showed that chess can lead to significant progress in problem solving, memory enhancement, focusing, scoring of IQ tests, creativity, critical thinking, visualizing, recognizing patterns, and enhancing meta-cognitive skills (Kazemi et al., 2012). Developing a successful intelligent tutoring system (ITS) for chess endgames would therefore have a significant practical value.

While our primary goal is to develop an efficient intelligent tutoring system that leads to *robust learning*, we deem the secondary goal to be equally important: to obtain a *formative evaluation* of our methods to support automated conceptualization of learning domains (Možina et al., 2012). The purpose of these methods is to partially automate the process of developing ITSs and thus considerably decrease the high costs of building them.

In the present paper, we present the development of the ITS for chess endgames. We describe in detail the architecture of the system and briefly address our future work. Our web-based tutoring application is available at http://www.ailab.si/chesstutor.

2 ARCHITECTURE

The basic architecture of our chess-endgame tutor is demonstrated in Fig. 1. The tutor uses three types of knowledge for teaching chess endgames:

- expert knowledge about the target chess endgame, stored in the *domain model*,
- pedagogical knowledge about the teaching strategies in this endgame, represented in the *tutoring model*,
- knowledge about the student and his or her learning progress, stored in the *student model*.

The other two components are the *user interface*, where the student and the tutor interact, and a *search engine* that enables the tutor to verify student problem-solving solutions and to generate appropriate feedback when required.

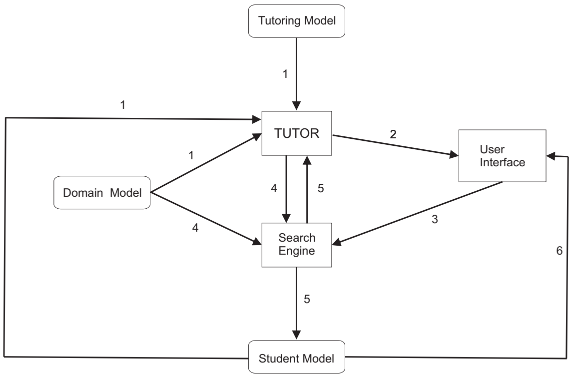

Figure 1: The chess-endgame tutor architecture. The arrows represent the data flow between individual components, and the numbers show the time order of the data interchange in a tutoring session.

2.1 A Cycle in the Tutoring Session

In a typical problem-solving session with the student, the task of the tutor is to present a chess problem (chess position with a suitable goal) with respect to the student's abilities and her current state of knowledge about the domain. For example, if the student has just failed to achieve the given goal from the same position on her previous attempt, the tutor may present additional information in various possible forms (e.g. hints, additional instructions, colored squares and arrows on the chessboard, etc.) to aid the student.

The student's solution to the problem, or a solution step, is received through the user interface. This information is validated on the fly in real-time by the search engine, to verify whether the student's move leads to the achievement of the given goal. If not, the tutor warns the student about the error, and the student can restart the problem or investigate why her solution is inappropriate. The search engine also plays an important role in the selection of a goal to be achieved next. The rules from the domain model are used to identify the candidate goals, and the search engine then evaluates which of these goals are achievable. Based on so-called *malrules* in the domain model, it may also detect possible misconceptions in the student's knowledge.

The output of the search engine represents the basis for the selection of the next tutorial action, and for an update of the student model. The tutor's representation of the student is available to her in a form of a *skill meter*, which represents an estimate of the student's mastery of particular skills (or goals). The skill meter is updated, and the tutor goes to the next cycle.

Fig. 3 displays the user interface of the tutor. On the top of the screen there is the navigation panel that enables switching between *tutor mode* and *play mode* (see Section 2.3 for explanations), access to instructions and example games, and information about the time spent. On the left-hand side there is a large chess board, with navigation buttons and last few moves played below. On the right-hand side there is a space for tutorial actions and the skill meter.

2.2 Domain Model

Chess endgames are a *well-defined problem-solving* domain. Even elementary chess endgames can be sufficiently complex and thus interesting to learn. In an endgame of king, bishop, and knight versus a lone king (also known as KBNK), for example, even optimal play in a checkmating procedure may take as many as 33 moves. There are many recorded cases when strong players, including grandmasters, failed to win this endgame.

We use a rule-based domain model. This type of domain models is typical for *cognitive tutors* that proved to be successful in improving student learning in a range of learning domains (Anderson et al., 1995; Koedinger et al., 1997; Koedinger and Corbett, 2006). The domain model was obtained semi-automatically as a result of *domain conceptualization*, as presented in (Možina et al., 2012) and (Guid et al., 2009).

2.2.1 Conceptualization of Domain Knowledge

Conceptualization of learning domains can be viewed as one of the key components in the construction of intelligent tutoring systems. The role of domain conceptualization is as follows. In complex domains, the connection between the basic domain theory (axioms, laws, formulas, rules of the game, etc.) and problem solutions is usually rather complex and hard for a human to execute. Therefore, there is typically a need for an intermediate theory, *conceptualized domain theory*, which serves as a bridge between the basic declarative domain theory and procedural knowledge for concrete problem solving.

In terms of a derivation chain, the basic domain theory (axioms, etc.) logically entails a "conceptualized domain theory," which in turn entails problem solutions. Logically, the basic domain theory also entails problems solutions, but at much higher problem-solving effort. The basic theory is typically "non-operational" for a human (requires excessive computation, or it may be too complex to memorize), whereas the conceptualized theory is "human-assimilable." These relations are illustrated in Fig. 2.

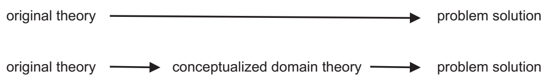

Figure 2: The result of a domain conceptualization. Arrows indicate derivation, and the length of an arrow indicates the complexity of the derivation.

A conceptualized domain is a problem-solving tool for a human, and therefore should be simple and compact, so that it can be understood, memorized, and executed by the student.

Fig. 4 shows a problem state space in a typical problem-solving setting. The circles represent problem states, and arrows represent available actions. In domains of any interest the solution path requires too excessive computation, or it is too difficult to memorize for a student. To alleviate the student's task, we learn intermediate goals that can lead the student reliably towards the solution of the problem (see Fig. 5).

Our rule-based model consists of no more than 11 *production rules*, i.e., if-then statements suggesting goals to be achieved when some conditions are met. They are slightly adapted from (Guid et al., 2009).

Block the Way to the Wrong Corner

The goal can be achieved in 2 moves.

You are on the right track.

Deliver Checkmate
Restrain Defending King to A Minimal Area Beside The Right Corner
Squeeze Defending King
Build A Barrier around Defending King
Approach Defending King from Central Side
Block the Way to the Wrong Corner
Push Defending King Towards The Right Corner
Push Defending King Towards the Edge
Approach With the King
Bring the Knight Closer to the Defending King
Keep the Kings Close

1. *Kf5-f6 Kh7-h8*

Figure 3: The chess-endgame tutor user interface.

Each production rule contains one goal, achievable in *d* plies (i.e. half-moves). This *depth* parameter is fixed and is set prior to conceptualization of domain knowledge. It enables to adapt the level of conceptualization to the skill level of a targeted group of students, since it determines to some extent the complexity of learned rules (Mozina et al., 2010).

The goals are achievable in up to *d* plies, typically in several possible ways and move orders. The search engine verifies on the fly whether the student's move is correct or incorrect in the sense of achieving the given goal. Moreover, the search engine can also evaluate whether the move is acceptable (in terms of approaching to checkmate) even in cases when it actually fails to achieve of the goal – in such a case the student will receive a different type of feedback as if the move was entirely bad.

2.3 Tutoring Model

The cognitive theory underlying our chess-endgame tutor is compatible with the ACT-R learning theory (Anderson and Lebiere, 1998). The *model-tracing* approach to intelligent tutoring is used: the tutor assesses and interprets students' solution steps by comparing what the student does in any given situation against the appropriate rule in the domain model (Anderson et al., 1995). The production rules guide a student reliably towards the final goal of achieving checkmate within the allowed 50 moves, even with a slowest possible realization of strategic goals (Guid et al., 2009).

The tutor operates in two different modes:

Tutor Mode. represents the main learning environment and thus the most important part of the tutor. It enables the student to practice her skills in a problem-solving context, executing suggested goals and receiving feedback by the tutor.

Play Mode. enables the student to test or practice her skills in playing the endgame against the computer, without any interventions by the tutor. The student only has basic hints on disposal, given on demand only. No move retracts are possible.

Beside text-based explanations the tutor also has an

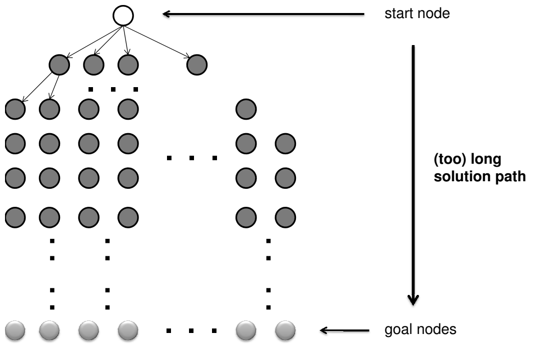

Figure 4: Problem state space in interesting domains.

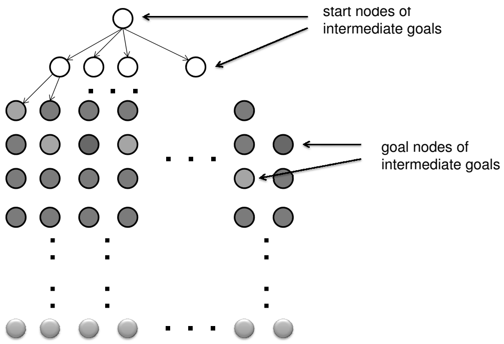

Figure 5: The role of intermediate goals.

option to use colors and arrows on the chessboard display when giving feedback to the student. For example, to mark the squares that limit the area available to the opponent's king.

2.4 Student Model

In our chess-endgame tutor, the role of the student model is primarily to help correct "incomplete" student knowledge, and to help diagnose bugs in the student's knowledge. The knowledge is represented in a form of a skill meter (see Fig. 3 on the right side), aiming to show the level of student's understanding of particular skills. Each of the skills corresponds to one production rule in the domain model. We use one of the most popular methods for estimating students' knowledge, that is *Bayesian Knowledge Tracing model* (Corbett and Anderson, 1995). The model uses four parameters per skill, which were in our case tuned arbitrarily with the help from a chess expert and will be continuously updated using student performance data, to relate performance to learning as well as possible. We use an *open student model* to support students in evaluating their own learning (Bull and Kay, 2007). The skill meter may assist the student in making the choice of which skill to focus on: the tutor allows the student to pick a random position featuring the goal associated with particular skill.

3 CONCLUSIONS AND FUTURE WORK

We followed some commonly accepted guidelines for building intelligent tutoring systems and applied them to the domain of chess endgames. The tutor is based on a rule-based domain model that represents the result of using our methods for semi-automatic domain conceptualization (Možina et al., 2012).

The main line of the future work is to evaluate the proposed system. This includes both:

- *Summative Evaluation*: to examine the overall educational impact of the tutor,
- *Formative Evaluation*: to assess the effectiveness of the evolving design, in particular with respect to usability of our semi-automatically derived domain model.

One of the features of our web-based application is an ability to record students' actions and times spent on executing them. These data will represent the basis for an assessment of student acquisition of skills and understandings. As another aspect of the evaluation, we intend to evaluate the applications' usefulness and its pedagogical abilities (Giannakos, 2010).

We also plan to extend the domain model to include several additional chess endgames.

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Evaluating Mobile Learning Adoption in Higher Education based on New Hybrid MCDM Models

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Keywords: Mobile Learning, MCDM (Multiple Criteria Decision-Making), DEMATEL, DANP (DEMATEL-based ANP), VIKOR.

Abstract: This study investigated the mobile learning adoption of evaluation in higher education. Mobile learning is a new form of learning utilizing the unique of mobile devices. However, students' readiness for mobile learning has yet to fully explore in Taiwan. The purpose of this study is to address this issue using a hybrid MCDM (multiple criteria decision-making) approach that includes the DEMATEL (decision-making trial and evaluation laboratory) for constructing influential network relationship, DANP (DEMATEL-based ANP) for finding the influential weights, and VIKOR methods combining the influential weights of DANP for evaluating the performance gaps in each criterion and then how based on influential network relationship map (INRM) to reduce gaps for achieving aspiration level. An empirical case as example is illustrated to show that these hybrid MCDM. By evaluating the influential interrelationships between criteria related to mobile learning, this approach can be used to solve interdependence and feedback problems, allowing for greater satisfaction of the actual needs of mobile learning behaviour.

1 INTRODUCTION

This study contributes in higher education in three ways. First, the adoption of mo-bile learning is explored from a multi-faceted perspective including attitude-related behaviors to mobile learning, perceived behavioral control, and trust-related behaviors. This implies that university practitioners should consider these three fac-tors before employing m-learning. Second, the current study shows the relative im-portance of perceived behavior control (i.e., perceptions of internal and external con-straints on behavior) (Taylor and Todd, 1995) in the decision to adopt mobile learning. That is, students who are confident with mobile devices are likely to adopt mobile learning. Hence, universities need to provide students with training opportunities about the basic functions and applications of mobile learning technologies. Lastly, the current findings reveal that usefulness and ease of use affect students' attitude for adopting mobile learning. Thus, to facilitate the acceptance of mobile learning, the learning environment should be perceived as useful and easy to use. A better understanding of the process of mobile learning adoption will help researchers and decision makers work together to implement proper strategies for mobile learning.

Most of the conventional multi-criteria decision analysis (MCDA) models cannot handle the analysis of complex relationships among different hierarchical levels of criteria. Yet the decision to adopt mobile learning requires decision model that does just that. The purpose of the present study is to address these issues; we develop a hybrid MCDM model that combines DEMATEL, DANP, and VIKOR. The hybrid method overcome the limitations of existing decision models and can be used to help us analyze the criteria that influence mobile learning issue. In particular, we use Taiwan's college students as an example to study the interdependence among the factors that influence the user behavior of mobile learning in the higher education as well as evaluate alternative user behavior processes to achieve the aspired levels of performance from mobile learning.

2 METHODLOGY

This Section comprises four parts: the first part presents the DEMATEL technique for building an influential network relationship; the second part calculates the influential weights using DANP (DEMATEL-based ANP); the third, the last part uses VIKOR to evaluate total accreditation performance; finally, describes the data collection.

2.1 DEMATEL for Establishing an Influential Network Relationship

DEMATEL is mainly used to solve complex problems to clarify their essential nature. DEMATEL uses matrix and related mathematical theories (Boolean operation) to calculate the cause and effect relationships involved in each element. This technique is widely used to solve various complex studies, and particularly to understand complex problem structures and provide viable problem-solving methods (Tzeng *et al.*, 2007). DEMATEL is based on the concept of influential relation map, which can distinguish the direct/indirect influential relationship of the criteria, allowing decision-makers to identify the key criterion for developing strategies for improving accreditation performance in higher education of this study.

2.2 Find the Influential Weights using the DANP

This study not only uses the DEMATEL technique to confirm the interactive relationship among the various dimensions/criteria, but also seeks the most accurate influential weights. This study found that ANP can serve this purpose. This study used the basic concept of ANP (Saaty, 1996), which eliminates the limitations of Analytic Hierarchy Process (AHP) and is applied to solve nonlinear and complex network relations (Saaty, 1996). ANP is intended to solve interdependence and feedback problems of criteria. This study thus applies the characteristics of influential weights ANP and combines them with DEMATEL (call DANP, DEMATEL-based ANP) to solve these kind of problems based on the basic concept of ANP. This approach yields more practical results.

2.3 Evaluating Competitiveness Gaps using VIKOR

Opricovic and Tzeng (2004) proposed the compromise ranking method (VIKOR) as a suitable technique for implementation within MCDM (Tzeng et al., 2005; Opricovic and Tzeng, 2004; Opricovic and Tzeng, 2007; Liu and Tzeng, 2012). VIKOR uses the class distance function (Yu, 1973) based on the concept of the Positive-ideal (or we adopt the Aspiration level) solution and Negative-ideal (or we adopt the Worst level) solution and puts the results in order. For normalized class distance function it is better to be near the positive-ideal point (the aspiration level) and far from the negative-ideal point (the worst value) for normalized class distance function.

2.4 Data Collection

Table 1 descripts the framework of dimensions and criteria. And the data was collected from 32 education experts who understand mobile learning trend and usage (in consensus, significant confidence is 96.375%, more than 95%; i.e., gap error =3.265%, smaller less 5%). Most of the education experts have teaches more than ten years in higher education. Expert perspectives on all criteria within the criteria were collected via personal interviews and a questionnaire. Expert elicitation was conducted in Nov., 2012, and it took 60 to70 minutes for each subject to complete a survey.

Table 1: Framework of dimensions and criteria.

Dimensions	Criteria
Attitude-related behaviours $\boldsymbol{D}_1$	Relative advantage C_1
	Compatibility C_2
	Complexity C_3
Perceived behavioural control $\boldsymbol{D}_2$	Self-efficacy C_4
	Resource facilitating conditions C_5
	Technology facilitating conditions C_6
Trust-related behaviours $\boldsymbol{D}_3$	Disposition to trust C_7
	Structural assurance C_8
	Trust belief C_9

3 EMPIRICAL STUDY ANALYSIS FOR MOBILE LEARNING ISSUE

In this section, an empirical study is displayed to illustrate the application of the proposed model for evaluating and selecting the best method that can help decision makers to understand how to improve their evaluations of mobile learning user-behaviour.

3.1 Analysis of Result

In this paper, we confirmed DEMATEL decision-making structure, and analysed from three dimensions with 9 criteria of the user-behaviour perspective on mobile learning. According to the expert questionnaires, we obtain the total influence matrix ***T*** of dimensions and criteria shown in Table 2 to Table 3. We find the cognition and opinion from experts in three dimensions, and the relationship between the extents of the impact can also be found which is compared to other dimensions as show in Table 2.

Table 2: The total effect matrix of $\boldsymbol{T}_D$ and sum of effects on dimensions.

D	D_1	D_2	D_3	d_i	s_i	$d_i{+}s_i$	$d_i{-}s_i$
D_1	0.827	0.813	0.817	2.457	2.532	4.989	-0.075
D_2	0.888	0.784	0.822	2.494	2.338	4.832	0.156
D_3	0.817	0.741	0.767	2.325	2.406	4.730	-0.081

According to the total influence prominence $(d_i + s_i)$, "attitude-related behaviours (D_1)" has the highest influence of the strength of relationship that means the most important influencing dimensions; in addition, "trust-related behaviours (D_3)" is all the factors that affect the least degree of other dimensions. According to the influence relationship $(d_i - s_i)$, we can also find "perceived behavioural control (D_2)" is the highest degree of influence relationship that affects other dimensions directly. Otherwise, "trust-related behaviours (D_3)" is the most vulnerable to influence that compare with other dimensions. According to Table 3, we can obtain all the criteria of the impact of relations with each criterion. And then, from Table 4 shows the relationship between the extents of the direct or indirect influences and compares them with other criteria. "Technology facilitating conditions (C_6)" is the most important considerations criteria; in addition, "structural assurance (C_8)" is the influence of all criteria in the least degree of other criteria. Furthermore, we can also find in Table 4 that shows "self-efficacy (C_4)" is the highest degree of influence relationship in all the criteria. And, "technology facilitating conditions (C_6)", is the most vulnerable to impact of criteria that compare with other criteria.

We use DEMATEL to confirm the influence relationship with the criteria, and expect to obtain the most accurate influence weights. The purpose of DANP is to solve the interdependence and feedback problems of each criterion (Saaty, 1996). Therefore, we structure the quality assessment model by DEMATEL which combination with DANP model to obtain the influential weight of each criterion as show in Table 4.

Table 3: The total effect matrix of $\boldsymbol{T}_c$ for criteria.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1	0.773	0.848	0.901	0.738	0.768	0.978	0.836	0.790	0.919
C_2	0.868	0.827	0.920	0.805	0.816	1.011	0.865	0.804	0.921
C_3	0.802	0.812	0.695	0.656	0.687	0.858	0.734	0.680	0.801
C_4	0.886	0.940	0.911	0.662	0.784	0.979	0.833	0.774	0.902
C_5	0.787	0.857	0.833	0.690	0.617	0.872	0.743	0.704	0.815
C_6	0.920	0.954	0.902	0.778	0.795	0.879	0.859	0.815	0.956
C_7	0.882	0.882	0.863	0.702	0.737	0.941	0.729	0.800	0.925
C_8	0.690	0.698	0.673	0.550	0.580	0.731	0.680	0.541	0.740
C_9	0.885	0.894	0.882	0.728	0.748	0.954	0.871	0.809	0.805

Table 4: The gap evaluation of mobile learning by VIKOR.

D/C	Local Weight	Global weight (DANP)	Mobile learning gap (r_{kj})
D_1	**0.348**		**0.197**
C_1	0.329	0.115	0.113
C_2	0.339	0.118	0.213
C_3	0.332	0.116	0.266
D_2	**0.322**		**0.296**
C_4	0.300	0.097	0.228
C_5	0.310	0.100	0.366
C_6	0.389	0.125	0.294
D_3	**0.331**		**0.295**
C_7	0.331	0.109	0.266
C_8	0.310	0.102	0.338
C_9	0.359	0.119	0.284
Total gaps			**0.261**

In addition, we can find the critical criteria in higher education of mobile learning user behaviour are identified as technology facilitating conditions (C_6), trust belief (C_9) and compatibility (C_2). Furthermore, the influence weights combine with the DEMATEL technique to assess the priority of problem-solving based on the gaps identified by VIKOR method and the influence network relationship map.

An empirical study involving mobile learning user behaviour in the multiple stages (intention stage and adoption stage) are used to evaluate and improve the total accreditation gaps using the VIKOR method, as listed in Table 4. Decision makers can identify problem-solving issues according to this integrated index, either from the perspective of the criteria as a whole or from that of an individual dimension.

Using the overall/dimension criteria, the gap values can be determined by the priority sequence improvement for reaching the desired level. In the intention stage, resource facilitating conditions (C_5), with a higher gap value of 0.366, are the first criterion to be improved.

Improvement priority can also be applied to the individual dimension. In the attitude-related behaviours (D_1) of the intention stage, for instance, the priority gap values are ordered as follows: complexity (C_3) , compatibility (C_2) , relative advantage (C_1) . In the perceived behavioural control (D_2) of the intention stage, the priority gap values are ordered as follows: resource facilitating conditions (C_5) , technology facilitating conditions (C_6) , self-efficacy (C_4) . In the trust-related behaviours (D_3) of the intention stage, the improvement priorities can be sequenced as follows: structural assurance (C_8) , trust belief (C_9) , disposition to trust (C_7) . Using the gap values provided by the panel experts above, improvement priority schemes are unique and comprehensive, both from the separate dimensions and from the overall points of view, as shown in Table 4.

For decision makers, understanding improvement priorities of mobile learning user behavior for client must be easier to understand than the gaps in higher education.

3.2 Discussions and Implications

The empirical results are discussed as follows. First, according to the DEMATEL model, we could recognize the interrelationship of each dimension and criterion the influential relationship network map for each dimension and criterion (as Fig. 1 shows). In Fig. 1, the perceived behavioral control (D_2) is affecting other dimensions- attitude-related behaviors (D_1) , and, trust-related behaviors (D_3) ; visibly perceived behavioral control (D_2) plays an important role and it has the highest and intensity influence in its relationship to other dimensions. Thus, higher education leader should first improve it, then, followed by attitude-related behaviors (D_1), trust-related behaviors (D_3) for evaluating and improving the mobile learning user behaviors in the higher education.

Second, after analyzing the dimensions, we would illustrate the considered-criteria in each dimension. According to the results, we illustrate the influence relationship-digraph-map of criteria in Fig. 1. Hence, for the influence relationship of these criteria, in the attitude-related behaviors dimension (D_1) : compatibility (C_2) was the most influence criterion and should be improved first, followed by relative advantage (C_1) and complexity (see Fig. 1 for more details on the causal relationship in D_1 , D_2 ,and D_3). Each of the evaluation dimensions and criteria creates the necessary behaviors for inducing mobile learning user behaviors in the higher education. Therefore, high education leader should evaluate all of the dimensions and criteria for the mobile learning user behavior in accordance with Fig. 1. This evaluation method can be used in most of the higher education. However, school leader should keep in mind that, when applying this model, some differences exist. The level of importance for the 9 criteria may vary according to the particulars of each high education, and the school leader should compare the evaluation methods for each mobile learning user behavior model before making deciding upon the optimal using adoption method.

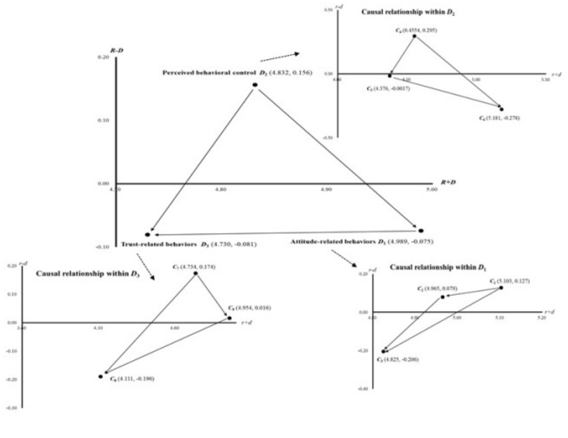

Fig. 1: The influential network relationship map of each dimension and criterion

Finally, the overall gap values (i.e., the distance to 0) shown in Table 4 that indicate room for improvement are 0.261 in the intention stage, and 0.235 in the adoption stage. In the multiple-stage perspective, the perceived behavioral control (D_2), featuring the largest gap value of 0.296 in intention stage, and the trust-related behaviors (D_3) featuring the largest gap value of 0.295 in adoption stage, which should be the first priority for improvement if decision makers wish to achieve the desired level. For long-term improvement, the decision makers should manage internal motivation carefully, as mentioned above. Given these empirical findings, our results, as holistically formulated in Table 5, fulfil the purpose of this research. Evaluating the mobile learning user behaviour model provided by this study can extend to most higher education using mobile learning user behaviour. However, school administrators should be cautious when applying this model. The importance of the 9 criteria may vary according to the situation, and administrators should compare the mobile learning user behavior and define the gap in that stage before making decision on optimal technology use.

Table 5: Sequence of improvement priority for mobile learning user behaviour.

Formula	**Sequence of improvement priority**
F1:Influential network of dimensions	$(D_2),(D_1),(D_3)$ $(D_1):(C_1),(C_2),(C_3)$ $(D_2):(C_4),(C_5),(C_6)$
F2:Influential network of criteria within individual dimensions	$(D_3),(D_2),(D_1)$
F3:Sequence of dimension to rise to aspired/desired level (by gap value, from high to low)	$(D_1):(C_3),(C_2),(C_1)$ $(D_2):(C_5),(C_6),(C_4)$ $(D_3):(C_7),(C_9),(C_8)$
F1:Influential network of dimensions	$(D_2),(D_1),(D_3)$ $(D_1):(C_1),(C_2),(C_3)$ $(D_2):(C_4),(C_5),(C_6)$

4 CONCLUSIONS

Mobile learning service has an important role in the training of higher education. Its decisions are complicated by the fact that various criteria are uncertainty and may vary across the different product categories and use situations. Based on the export and literature review, we developed the three dimensions and 9 criteria that align with the mobile learning service of environment. So we applied the methodology of hybrid MCDM model combining DANP with VIKOR in empirical case. The main reason is among the numerous approaches that are available for conflict management, hybrid MCDM is one of the most prevalent. VIKOR is a method within MCDM; it is based on an aggregating function representing closeness to the ideal (aspiration level), which can be viewed as a derivative of compromise programming for avoiding "choose the best among inferior alternatives (i.e., pick the best apple among a barrel of rotten apples)". In a decision-making process, we used the global and local weights into alternatives performance, such as that in Table 5, to allow school leader to select the best mobile learning adoption factor. We haven't only selected the best factor, but also found how to improve the gaps to achieve the aspiration level in mobile learning service performances.

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Master's Degree Program for Applied Informatics in Education Majoring in Instructional Design and Distance Learning

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Keywords: Elearning, Distance Learning, Instructional Design, Educational Programmes, Applied Informatics, Pedagogy.

Abstract: The presentation will cover the context and development of higher education professional educational programme for Applied Informatics in Education which was created to answer the challengers of new ICTs rich educational environment. The program was initiated to train the specialists for emerging eLearning sphere having integrated competences in Technology, Pedagogy and Organization. The paper outlines the process of setting the educational programme goals, building the specialists professional portrait, target audience, learning content selection and structuring, used educational technologies for training and future development perspectives.

1 INTRODUCTION

It is a well-known fact that modern information and education environment is characterized by new type of resources, new groups of users and new types of interaction.

But as any other educational system (traditional incl.) at any level of education and in any subject area, any information and education environment of concrete learning process requires first of all projection of its model, expertize of its components, analysis, software choice or\and development for, secondly, further realization in learning and teaching.

Moreover both stages require work of certain groups of experts. The project stage: course developer, instructional (learning) designer, and realization stage: teacher, tutor and system administrator.

So, for the effective functioning of this new environment we need to rely on new professionals who have integrated professional competences in both stages of educational system building and who can assist teachers who are rather strange with the new environment and technicians who are rather far from pedagogical process.

The objects of professional activities of such specialists in modern ICTs-rich educational environment are all components of learning process as a system realized by specific means of ICTs. They are learner and groups of learners, teacher, learning content, and learning activities (processes) based on new pedagogical and information technologies used for learning.

2 BACKGROUND

Training and professional development of teachers for ICTs in education is carried out in Russia by several institutions in the frameworks of several programmes of all Russia informatization, education including:

Programmes of life long education (MSU, Yakutsk State University, University of People's Friendship, Moscow Pedagogical State University, and many others);

Programmes of in-service training (Institutes and Centers of In-service Training of Teachers);

Professional net communities (Russian Educational Portal, Russian Internet Pedagogical Council, Creative Teachers' Network, Omsk Educational Portal, Perm City Portal, NetCommunity of EFL teachers and others).

If the requirements for professional competence of modern teachers and system administrator as a supporter of ICTs learning process are rather developed in Russian education, and profession of tutor (coordinator) is realized in the system of post diploma courses and in-service training, the profession of instructional designer is hardly understood in Russian professional education in its triad: whome, what and how to teach.

The practice shows that usually its the teachers who do all the job for eLearning – develop and design courses, support and facilitate learning. But the practice shows as as well that its impossible to impose all the competences and responsibilities for the innovative learning process on them due to the age and lack of time. They need professional support for that. And this job can be realized by Instructional designers or so called specialists in ICTs in education.

Nowadays the Instructional design profession is critical for the growing e-learning and labour market. Instructional designers require deep understanding of educational processes and knowledge of change agentry to help transform the current academic systems into effective e-learning approaches. They should have not only organizational skills but also an ability to quickly integrate different knowledge from a wide range of fields including Pedagogy, Law, Computer Science and ICTs, Psychophysiology, Ergonomics, Marketing, Sociology, Cross-cultural Communication, Information Security, and Quality Assessment.

Moreover, training of IT-competent specialists in ICTs in education is more efficient and realized by some educational institutions not only in contact but at a distance. In this respect some best examples were studied and are mentioned here:

- Post-Bachelor, Master and Doctorate Degree in Distance Education, Post Bachelor on Educational Technologies, Instructional Design – (e.g. Athabasca University, Canada)
- Master Degree in Innovation, Doctorate Degree in E-Learning - (e.g. Leicester University, UK)
- Distant Courses for Teachers and Instructors Professional Development – (e.g. Universitat Oberta Catalunya, Spain).

The mostly needed specialists for modern information and education environment are the specialists of 2 levels. Russia currently needs two types of eLearning professionals. The first group are teachers, tutors and academic coordinators that can be trained for using ICTs as a part of current training programs in Education by introducing various elective courses. But to train professionals of the second group, instructional designers and media specialists for distant education, special undergraduate and postgraduate programs should be developed and deployed. This would include programs in ICTs in Education, Instructional Design, Distance Education, and Multimedia Production.

3 DISCUSSION

The first attempt to respond to this pressing need in Russia was made 2 years ago (2009) at MESI (www.mesi.ru) when the Chair of Applied Informatics in Education developed and introduced a new Master's Degree Program in Distance Education. Thus, students of Applied Informatics can choose a set of profile and elective courses to major in Instructional Design and Distance Learning.

As Applied Informatics today is used in different spheres and there is a need for ICTs advanced professionals in education, economics, management and other spheres, the decision was taken to construct the program on the basis of "Applied Informatics". But the applicants can be any Bachelor or Specialist Degree fellows, majoring in Management, Law, Education and ICTs. So, thought being not limited the applicants should have the basic professional ICTs skills and understand the process of creating information systems, to be able to construct private and corporate networks of integrated knowledge.

All these taken into consideration, the competence portrait of a specialist was formed by extracting certain sets of knowledge from necessary subject areas that are needed to work with professional objects: learning content, teacher, student and activities.

Thus, for example, Master on the profile of "Applied informatics in Education" (Distance Education) is a specialist in the field of design, development and organization of systems of distance learning at various levels of education and fields of knowledge.

Learning at the Master's degree program presupposes an in-depth study of the disciplines in the following areas:
modern pedagogical technologies of distance learning;

- psychology of the net pedagogical communication;
- design of educational systems and resources;

- instructional design technologies in distance learning;
- legal issues of distance learning;
- distance learning quality ensuring, monitoring and evaluation;
- information security of distance learning;
- fundamentals of scientific and research activity;
- basics of adult learning.

Master's degree student in the educational profile will obtain the following competencies:

- analysis, evaluation and forecast of the main trends of ICTs' application in education;
- analysis, assessment, design, development, implementation, evaluation of the effectiveness of the systems of distance learning in terms of pedagogy, technology and organization;
- study, analysis, classification and selection of information technologies and tendencies of their development for the solution of applied problems of distance learning;
- analysis, systematization, the selection and design of electronic educational resources for distance learning and many others.

Training at specialization "Applied Informatics in Education"(Bachelor of ICTs in Education) implies in-depth study of disciplines in the following areas:

- Modern educational and pedagogical systems in the information society
- Theory and techniques of training and education on the basis of information technologies
- Information technologies and systems in education
- Basics of pedagogical communication
- The creation, management and quality assessment of educational systems and environments
- Educational and copyright law in Internet.

Spheres of professional activities:

- Design and project
- Industry and technology;
- Organization and administration;
- Analysis and Research.

Bachelor of profile "Applied Informatics in Education" is a specialist in the field of eLearning, competent in the integrated use of pedagogical and information technologies in the educational process at different levels of education and for different subject areas, which obtains the abilities and skills in:

- Educational technologies
- Instructional design
- Analysis, development and organization of educational systems.

Methods and technologies of management and evaluation of information and educational technologies, learning resources and environments.

The perspectives of development of competent model at each programme level are seen in the introducing the greater range of profiles for different specialist in eLearning (e.g. majoring in Educational Law or Educational Technologies or Educational Project Management). Besides working with main vendors in the field of eLearning in assessment profile textbooks and in teaching specific elective courses are very crucial for the success of the educational programme in the market. Of course, one of the main goals of upgrading course content is to provide environment to build and assess it in professional networks (incl. international) by using open resources and inviting famous specialists in the field of eLearning.

So, all these authentic courses are aimed at training specialists competent in classifying, analysis, evaluation, development of e-learning recourses and adapting systems for different knowledge areas and education levels. As this urgent demand for skilled professionals is met, we anticipate an on-going need to update skills and pedagogies as technology platforms change, as e-learning evolves to mobile learning, and as the impact of learning analytics is felt on distance learning approaches for the future. Thus, new approaches to education require re-thinking the systems and skills for creating and sustaining change. And that can be done on net community based approach.

Training of such kind of specialists requires maximum realization of “learning by doing" approach. Both modern ICTs used in the University (eCampus, Adobe Connect Pro) and open educational resources and services (Google Docs, Wiki, Moodle) that are professional tools for the future graduates of the programme, provide opportunity for that.

Thus, a networked curriculum is built and implemented by the international team for MESI Master’s Degree educational programme in question.

As it was already mentioned, this educational programme is very specific as, primarily, it is new to Russian educational context in the times of e-learning economic sector being formed and demand for this kind of specialists being stronger felt that ever before, and, secondly, because the educational aims are at the same time the learning content and methods used by professors for postgraduate students as they should learn the profession by doing.

That is why the concept of student centered approach and constructivism, problem-based, project–based approaches and activity methods were chosen to both build integrated course curriculum and activities, and to teach and learn the course content.

As stated above the programme is a blend of core Computer Science courses and 10 specialized courses in modern educational technologies covering: the basics of distance learning, computer learning systems, legal issues of e-learning, pedagogy, basics of distance learning course creation, psychology of Internet communications, security of e-learning systems, and some others. Being lacked in specialists in this unique sphere the university was and is strongly interested in sharing this knowledge with those who are involved in similar projects and discuss the basic competences for instructional designers and the ways of selecting and training professionals for this role. In our case the course developers were the leading specialists in the field both from Russia (e.g. Kazan Federal University Professor in Legal Issues of Distance Learning and Information Security, Moscow specialists) and abroad (e.g. leading Canadian specialist in Instructional Design from Athabasca University).

Following the main educational tendencies and demands of the course curriculum not only the content is developed in cooperation with leading specialists of the subject area, but the students are involved in online seminars and lectures delivered by foreign professors (from Finland, UK, the Netherlands, Canada) thanks to MESI technical facilities (e-Campus, Adobe Connect Pro and so on), joint time and territory spread small group work, individual practical work with instruments and tools for development electronic educational resources.

Master's Degree Programme for Applied Informatics in Education majoring in Instructional Design was developed in 2009 and 11 students defended their Master's dissertation since that time carrying out projects for the real educational institutions and companies which undertake e-learning initiatives. All these final projects are coordinated by their employers' representatives and developed and assessed in the professional nets. They touched upon distance education systems development for educational institutions and corporations, content development for distance education (e.g. Google in teaching and learning, a DL Course on the Russian Language), research of ICT potential in education (Google, MindMaps, E-portfolios, Screencasts, etc.), systems of assessing quality in eLearning, etc.

This academic year students present, discuss and carry out their final papers in cooperation with other students of the same programme from Athabasca University (Canada) with the consultancy of Russian and Canadian specialists. ICT instruments (e.g. MESI Information Center of Disciplines and e-Campus) allow building small net communities of students around each course in cooperation with a teacher, foreign expert and a vendor representative.

Thus, for example the professor of the chair and scientific consultant of the department is Doctor Griff Richards, professor of University of Athabasca (Canada). Professor Richards carries both lectures for the students of the department (Basics of Instructional Design) and research seminar "Research Seminar in ICTs in Education" on the basics of research and development and project work for the staff and students of the department in English (See Fig.1).

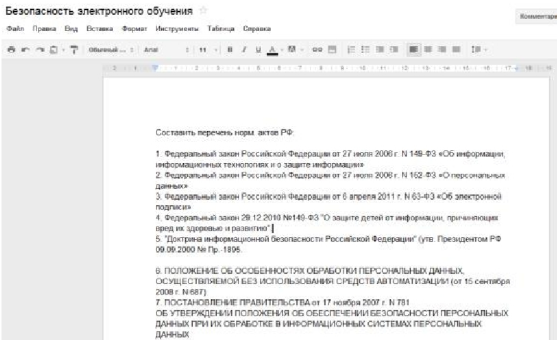
The dark side of open

Griff Richards, Ph. D.
Thompson Rivers University
Canada

Moscow, 08 December 2011

Figure 1: Online lecture of Prof. Richards from Canadian Athabasca University for the Master Degree students majoring in Applied Informatics in Education, delivered in Adobe Connect Pro.

Professor Zuev V.I., being a vice rector for information and distance learning technologies, is a unique specialist in Kazan Unstitute of Social and Humanitarian Sciences in Legal Issues of eLearning, Information Security of eLearning. Last two years Prof Zuev. teaches at the department of Applied Informatics in Education lecturing three core courses on the basis of modular system and blended learning, i.e. a week face-to face course is supported by students' project team work (see Fig. 2), as well as by his webinars (See Fig.3). Prof. Zuev is a scientific supervisor for a joint master's degree dissertation carried by a student from MESI and a student from Kazan. This year the successful joint dissertation defence was carried.



Составить перечень норм. актов РФ:

1. Федеральный закон Российской Федерации от 27 июля 2006 г. N 149-ФЗ «Об информации, информационных технологиях и о защите информации»
2. Федеральный закон Российской Федерации от 27 июля 2006 г. N 152-ФЗ «О персональных данных»
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6. ПОЛОЖЕНИЕ ОБ ОСОБЕННОСТЯХ ОБРАБОТКИ ПЕРСОНАЛЬНЫХ ДАННЫХ, ОСУЩЕСТВЛЯЕМОЙ БЕЗ ИСПОЛЬЗОВАНИЯ СРЕДСТВ АВТОМАТИЗАЦИИ (от 15 сентября 2008 г. N 687)
7. ПОСТАНОВЛЕНИЕ ПРАВИТЕЛЬСТВА от 17 ноября 2007 г. N 781
ОБ УТВЕРЖДЕНИИ ПОЛОЖЕНИЯ ОБ ОБЕСПЕЧЕНИИ БЕЗОПАСНОСТИ ПЕРСОНАЛЬНЫХ ДАННЫХ ПРИ ИХ ОБРАБОТКЕ В ИНФОРМАЦИОННЫХ СИСТЕМАХ ПЕРСОНАЛЬНЫХ ДАННЫХ

Figure 2: Google Docs used by Prof. Zuev (Kazan) for team work of students of MESI department (Moscow) in Information Security of eLearning.

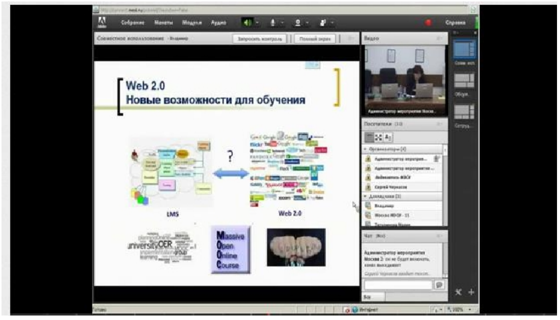

Figure 3: Webinar of Prof. Zuev carried for Master's Degree students majoring in Applied Informatics in Education in Adobe Connect Pro.

4 CONCLUSIONS

The initiative was welcomed by Russian educators and it stimulated introduction of this program in other Russian universities. New program profiles started to be developed. The program was quick scanned by E-xcellence, Quality Assurance in eLearning (EADTU) and achieved the label of Associates in Quality.

Priority perspectives of the department lie in both academic staff and students mobility, and educational programme mobility in Instructional (learning) design based in ICTs what is connected with attracting leading specialists of the field and eLearning vendor's representatives for teaching at the programme profile courses, providing opportunities for joint degree programmes realization in Russian and abroad in the field, international joint research and thesis defence.

Besides one if the leading priorities are focussed on programme content development for distance training and quality assessment (Virtual Chair on ICTs in Education), customized learning paths design, on-demand corporate training and partnership of business and education that can upgrade trained competences and provide professional growth for the students.

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Remote Lab Experiments
Preliminary Results from an Introductory Electronic Engineering Module

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Keywords: Remote Lab, Remote Experiment, Engineering Education, Web-based Education.

Abstract: A case study concerning the remote lab use in introductory module for Electronic Engineering studies is presented. During the preparation stage of a forthcoming lab session, students access remote experiments using web browser pages for each instrument which are fully controlled and acquire data in real time. Instead of using virtual instruments or performing only computer simulations students are able to accumulate experiences about the forthcoming lab session and thus prepare more efficiently for it. Preliminary research shows that there is a considerable improvement in students' performance.

1 INTRODUCTION

Facilities of the laboratories in higher educational institutions are generally insufficient when the number of students is considered. Implementation of a laboratory to meet the requirements has a very high price. For this reason there is an increasing tendency for the use of Remote as well as Virtual Laboratories. The former denotes that real lab equipment made accessible over the internet by second being virtual simulations only performed by dedicated software. Both types have advantages and drawbacks but they can be adapted to a course in order to broaden the students' perception and skills (Jeschke *et al.,* 2007; Jona *et al.,* 2011).

The use of remote experiments have received great attention during last years. Several projects have focused on the dissemination of such online experiments: The European LiLa project (Richter *et al.,* 2011), the iLabs project (Sancristobal *et al.,* 2010) of the MIT, the Australian LabShare project (Lowe *et al.,* 2008) as well as The Lab2Go project (Zutin *et al.,* 2010) aim at building an index of online labs by providing infrastructures for dedicated and specialized experiments. The use of these infrastructures for the introductory-core (first two semesters) level of an Engineering curriculum may be redundant. Based on this observation the Education Unit of Laboratory of Electric Characterization of Materials and Electronic Devices designs and offers a web-based remote lab providing a set of basic remote experiments that support the laboratory assignments of the core module "Introduction to Electronics" at 1st semester. The main factor that motivated this work was the fact that students have been observed to lack preparation prior to lab sessions.

In previous work the theoretical part of the module was supported by using electronic examinations and assessments of undergraduate students like multiple choice tests and virtual experiments (Tsiakas *et al.,* 2007; Triantis *et al.,* 2007; Ninos *et al.,* 2010)

The current paper presents the results of a preliminary study from the application of remote experiments run at the Department of Electronics during 2012-13 fall semester.

2 DESIGN APPROACH

The proposed system based on National Instruments' (NI) LabVIEW and Texas some type of remote access (usually web pages), the Instruments' (TI) TINA software. The architecture based on client-server lightweight approach meaning that all the critical (and process demanding) elements are relying on Lab's servers while students access their experiments through certified web browsers. The basic architecture of the system is presented on Fig.1.

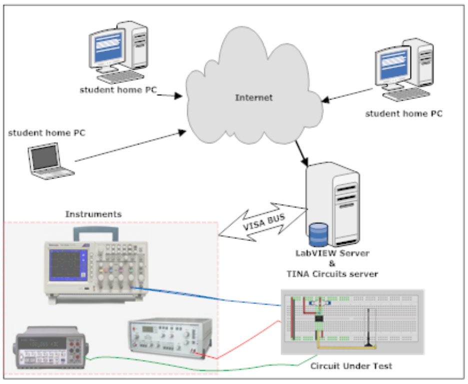


Figure 1: The architecture of the proposed system.

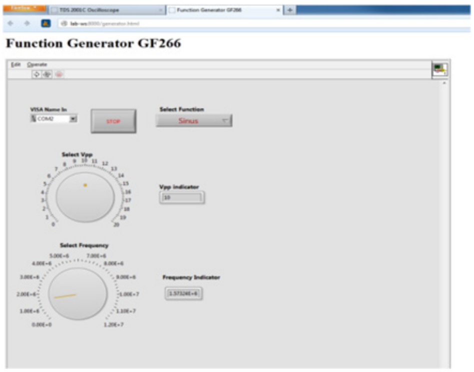
The basic elements of the design are as follows:

1) *The LaBVIEW Server*. The core of the system which runs on VPN servers. Each experiment hosted in a dedicated server which is accessed by web browsers in predefined ports. Configuration is straightforward using NI's knowledge base. Instruments controlled using the VISA interface and acquired data are stored also locally in order to avoid experiment termination in case of Internet failure.

2) *The instruments' remote panels*. For each instrument we design and implement a remote panel (RP) and subsequently transform this RP to a web page. Students access the corresponding web page for each instrument and functioning the RP. The LabVIEW controls and indicators were customized to look slightly different from the real controls of the controlled instruments. This was chosen in order to discourage students to "memorize" the function of each individual control instead of clearly understanding it. Typical examples of a signal generator and an oscilloscope are presented in Fig. 2 and Fig. 3

3) *The TINA 9 remote circuits*. For verification purposes, students require to run a simulation at the time that they perform the remote experiment. Using TI's TINA (which installed in their local hard disks) they have the ability (using TINA's internal web browser) to collect and run the corresponding circuit. Since TINA can run independently from RP web pages each student can run the remote experiment and at the same time checking the validity of acquired values by running the corresponding simulation.

4) *The booking system.* Since LabVIEW cannot provide access to two or more users simultaneously it is crucial to provide single user access through an effective booking system. This was achieved using a simple web form which checks the available timetable and informs the user for time-slot availability. Each student is provided by 90min session which is 30 min less than regular lab session. Booking can be made only once and if the student cannot use his session an alternate timetable is provided after the completion (by all students) of the remote experiment.


Function Generator GF266

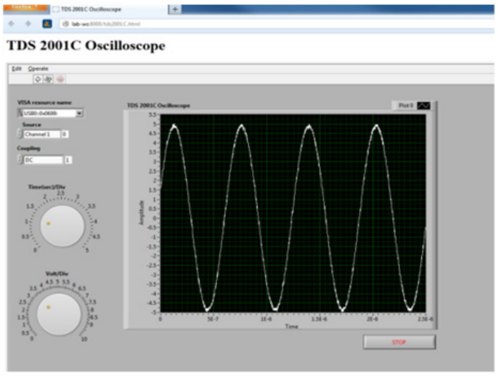
VISA Name In: COM2

Select Function: Sinus

Vpp Indicator: 10

Frequency Indicator: 1.57324E+6

Figure 2: Function Generator RP web page.


TDS 2001C Oscilloscope

Source: Channel 1

Coupling: DC

Figure 3: Oscilloscope RP web page.

3 METHODS AND DETAILS

The study was performed using results from multiple choice questions from 15 students. Initially the students follow the experiments' procedures using the traditional approach by completing the preparation steps (which includes simulations and calculations) before enter the lab. Then each student required answering in 10 questions regarding the experimental procedure as well as the interpretation of results. This was defined as Tn_{pre} phase. Then, instead of simulations, students run preliminary remote experiments in order to perform initial calculations. In correspondence with Tn_{pre} they called to answer the same set of 10 questions. This was defined Tn_{post} phase.

The evaluation of possible improvement by the use of remote experiment is examined by comparing students' results without (Tn_{pre}) and with (Tn_{post}) the use of remote experiments. Initially, results checked for their internal reliability by means of Cronbach's α value for each dataset (Cronbach, 1951; Cronbach & Shavelson, 2004).

The possible improvement is measured by means of Hake's gain g (Hake, 1998) which defined as follows:

$$g = \frac{Tn_{post} - Tn_{pre}}{\max\{Tn\} - Tn_{pre}}$$

where n: number of test
$max\{Tn\}$: test's maximum score

Hake's gain has been accepted as an important measuring parameter for teaching efficiency because as weighing the students' improvement, the effects from their different level of previous knowledge is corrected (Lenaerts et. al, 2003).

An additional questionnaire was supplied to students in order to investigate the usability and the global satisfaction from remote lab's use.

4 RESULTS AND DISCUSSION

Our preliminary results derived from two curriculum subjects: low and high pass filters. For each subject we perform a multiple choice test thus we present results for tests T1 and T2.

Results for the calculation of Cronbach α are presented in Table 1. Internal consistency of results can be characterized as accepted since all $\alpha > 0.7$ (Cortina, 1993). In all cases the results follow normal distribution according to Kolmogorov-Smirnov test (Stuart et. al, 1999).

Table 1: Cronbach's α results for both tests.

Test phase	Cronbach α
$T1_{pre}$	0.862
$T1_{post}$	0.809
$T2_{pre}$	0.779
$T2_{post}$	0.721

In Table 2 we present the results from all the students per question as well as the improvement according to Hake's g. The average number of students that gave correct answers per question increased from 21% to 50% for Test1 and from 31% to 53% for Test2. These correspond to Hake's improvement 0.37 and 0.33 correspondingly.

Table 2: Successful results per question (Q) for two experiments (T1 & T2).

Q	$T1_{pre}$	$T1_{post}$	g	$T2_{pre}$	$T2_{post}$	g
1st	4	9	0.45	6	10	0.44
2nd	3	10	0.58	4	8	0.36
3rd	1	7	0.43	5	8	0.30
4th	4	10	0.55	2	6	0.31
5th	0	6	0.40	1	6	0.36
6th	5	6	0.10	7	10	0.38
7th	2	4	0.15	5	9	0.40
8th	3	6	0.25	5	7	0.20
9th	4	8	0.36	5	8	0.30
10th	5	9	0.40	6	8	0.22
Average per Q	*3.1*	*7.5*	*0.37*	4.6	8	*0.33*

Results indicate that by using remote lab experiments, students were able to improve their performance. The improvement is quite similar between the two tests.

Students' perception toward the remote lab indicated a positive evaluation from students. Usability and overall achievement level earned higher scores in contrast with global satisfaction which earns controversial scores (very high and very low). Results are presented in Fig.4

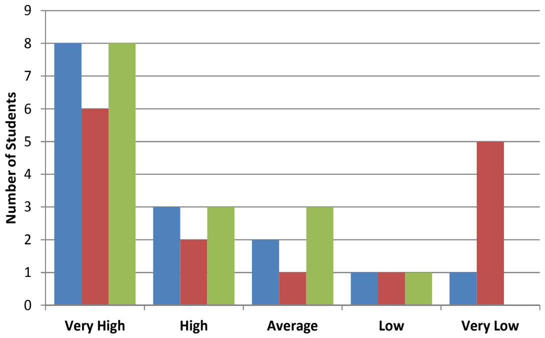


Figure 4: Student survey results: System's Usability (blue bar), Students' opinion on contribution of the Remote Lab to overall achievement level (red bar) and global satisfaction from the complete system (green bar).

Subsequent conversations clarified the latter aspect as a result from the students that graduated from General High schools (as opposite to Vocational High School graduates who had lab experience). Students that didn't have previous experience with physical instruments present a lack of understanding the potential benefits of the remote lab than actually using the real instrumentation.

5 CONCLUSIONS

The current paper presents preliminary results of case study from the use of a remote lab in an introductory course in Department of Electronics at TEI of Athens. Using the National Instruments' LabVIEW and Texas Instruments' TINA we implement a web-based system for remote lab capable of providing experiments using real instruments. Students use their web browsers to control and collect data from real instruments while they have the ability to run simulations on the measured circuit using TINA's web offered circuits.

Preliminary results using multiple choice questions are presented in order to investigate if and how the use of remote experiments benefits students' perception. Using Hake's *g* measure we estimated that initially there is an improvement in performance which of course is a subject for future work.

Finally a non-measurable parameter that is observed to benefit from the application of remote lab is the time that each instructor consumes in order to introduce and explain each experiment. There was a drastic decrease in time spent by the instructors for the students that used the remote lab. This fact can lead to disperse instructors' time to more personalized sessions with students that show lack of performance.

Future research will focus on the applicability of the proposed system to advanced courses as well as to the elimination of operational drawbacks (e.g. automatic selection of optimum timeslots, booking changes, elimination of overbooking e.t.c)

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LEARNING/TEACHING METHODOLOGIES AND ASSESSMENT

FULL PAPERS

Comparison of Two Cognitive Strategies for Learning from Illustrated Texts

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Keywords: Multimedia Learning, Text-picture-Combinations, Learning Strategies, Cognitive Ability, Think Aloud.

Abstract: Learning from illustrated text is often expected to be more beneficial than learning from text alone. Nevertheless, learners often fail to adequately process text-picture-combinations. One option to support learners and foster learning would be to provide them with strategies for learning from text-picture-combinations. Up until now, however, such comprehensive strategies have not been available. We have therefore conceptualized two strategies, based on current models of multimedia learning, for learning from text-picture-combinations. Both strategies aim to enhance the same cognitive processes by encouraging either internal, or internal and external learning activities. An experimental study was conducted to investigate whether sixth-grade students with varying cognitive abilities (high vs. low ability) apply the two strategies differently. Within both levels of ability, learning with the strategy that encourages internal and external learning activities led to superior learning gains. An analysis of think aloud data revealed differences in the quality of the students' strategy use.

1 INTRODUCTION

Learning with the computer is typically equated with multimedia learning, which Mayer (2005) defined as: "presenting both words (such as spoken text and printed text) and pictures (such as illustrations, photos, animation, or video)" (p.2). On the basis of this definition, text-picture-combinations can be understood as a fundamental form of multimedia learning. Therefore, research on text and picture can also be revealing for learning with the computer in general.

It is believed that adding pictures to a text fosters learning. Furthermore, research shows that students learn more from an illustrated text than from text alone (e.g. Mayer, 2001). Learners, however, do not automatically process texts and pictures appropriately. They often have difficulty encoding complex pictures or combining information provided in the text and the picture (e.g. Ainsworth et al., 2002; Levie and Lentz, 1982). How can learners therefore be supported to successfully process text-picture-combinations?

One approach to support learning is to improve the design of the learning material. Over the past 15 years, various principles for improving the design of text-picture-combinations have been proposed and empirically evaluated (e.g. Mayer, 2005). Research has demonstrated, however, that the principled design of learning material alone does not guarantee successful learning; even well designed material does not necessarily lead to an active processing of the representations (e.g. Bartholomé and Bromme, 2006; Dean and Kulhavy, 1981). An active processing of the text and picture information is essential to understanding the learning material (Wittrock, 1990). Moreover, learners are often confronted in daily life with materials that are not "well" designed (cf. Mayer, 1993).

Research on text understanding has shown that learning strategies which take a more learner-orientated approach can effectively support learning (e.g. Dansereau et al., 1979; Mandl and Friedrich, 2006). According to our knowledge, there are currently no comprehensive strategies available for learning from text-picture-combinations, and only a few isolated techniques for learning from pictures (e.g. Peeck, 1994; Seufert, 2003) have been proposed up until now. Based upon previous strategic learning research and current models of multimedia learning, we have developed two learning strategies which aim to systematically foster learning from illustrated texts. While one strategy encourages internal learning activities, the other strategy encourages internal and external learning activities. An experimental study was conducted to analyze whether learners with varying cognitive abilities apply the two strategies differently.

2 PREVIOUS RESEARCH ON STRATEGIC LEARNING WITH TEXT AND PICTURES

According to Streblow and Schiefele (2006), a learning strategy is defined as "... a sequence of efficient learning techniques, which are used in a goal-orientated and flexible way, are increasingly automatically processed, but remain consciously applied" (p. 353; translation by the authors). Thus, learning techniques, such as underlining important statements in a text or annotating a text or picture, are individual components of a strategy. Several learning techniques combined together in a goal-orientated way form a learning strategy.

Early research on learning strategies was mainly oriented towards text. Models which describe relevant processes for text understanding were formulated on a theoretical level (e.g. Kintsch and van Dijk, 1978). On an empirical level, Marton and Säljö (1984) identified two approaches to learning. They differentiated between a surface level approach and a deep level approach. In the surface level approach, learning focuses mainly on the repetition of information in order to remember it. In the deep level approach, elaborative activities lead to an understanding of the information. It has been repeatedly demonstrated that text comprehension is improved when learners utilize the deep level approach (see also Dornisch et al. 2011; Schlag et al., 2007). On the basis of these theoretical models and empirical findings, different strategies which aim at fostering relevant deep level processes have been developed and evaluated. Examples are the PQ4R-Method (Preview, Question, Read, Reflect, Recite, Review, Thomas and Robinson, 1972) and the MURDER strategy (Mood, Understanding, Recall, Digest, Expanding, Review, Dansereau et al., 1979; for an overview see Mandl and Friedrich, 2006).

Current learning materials, however, consist not only of text but include large numbers of illustrations as well. Mayer (1993) has already shown that half of the space in an average science textbook is reserved for pictures. This development was taken into account at the theoretical level by conceptualizing processing models for learning with illustrated texts (e.g. Mayer, 2001; Schnotz and Bannert, 2003). These models describe processes which are considered to be essential for learning from illustrated texts. Up until now, however, only a few approaches which foster strategic learning from text-picture-combinations have been proposed. In addition, a few isolated techniques have been developed with respect to facilitating learning from pictures, e.g. learners were requested to pay attention to a picture (Peeck, 1994) and to answer questions concerning a picture (Peeck, 1994; Weidenmann, 1994).

3 CONCEPTUALIZATION AND EVALUATION OF A LEARNING STRATEGY

When developing strategies for learning from text-picture-combinations, it is necessary to first identify the processes relevant for learning. Various processing models for learning from text-picture combinations consider similar processes to be important for learning (Mayer, 2001; Schnotz and Bannert, 2003). For instance, in his model of multimedia learning, Mayer (2001) emphasizes three kinds of cognitive processes: *selection*, *organization,* and *integration of information*. Furthermore, the model assumes *transformation processes*.

Selection processes aim at selecting relevant internal and external information. When learning with text-picture-combinations, special attention should be given so that the relevant information from both sources is selected. *Organisation processes* take place when the selected information is correlated to each other. *Integration processes* integrate information from the text and pictures, as well as prior knowledge, into one coherent mental model. *Transformation processes* occur when verbal representations are transformed into pictorial representations and vice versa. Since each of these processes might take advantage of prior knowledge, we do not consider elaborations to be a separate process category. Rather, we assume that each of these processes can fulfill elaborative functions.

Already existing models of multimedia learning served as the foundation for developing a strategy for learning from text-picture-combinations. For each process mentioned above, learning techniques that aim to induce the relevant processes were formulated. While some techniques could be taken directly from literature on learning from texts and learning from pictures, other techniques had to be constructed by drawing an analogy to already existing techniques. For example, a common technique which supports text comprehension is to identify and underline relevant phrases. A possible analogous technique to support picture comprehension could be to identify and mark relevant entities within the picture. The formulated techniques promote internal as well as external learning activities (cf. Table 1); the external learning activities (e.g. underlining) thereby facilitate internal learning activities (e.g. selection of phrases).

Table 1: Strategy to encourage internal and external learning activities.

Cognitive processes	Learning technique
Selection and organization	a) *Get an overview:* Shortly read the text and look at the picture in order to get an overview. b) *Identify relevant aspects in the text and picture*: Underline the phrases in the text that are important to you. Search for entities in the picture that correspond to the phrases and mark them. Now label the marked entities with the underlined phrases.
Integration and transformation	c) *Establish relations between the text and picture:* Write a summary of what is represented on the whole in the text and picture. d) *Visualize important information*: Draw a sketch that illustrates which information from the text and picture is most important to you.

An experimental study was conducted to evaluate the effectiveness of the strategy (Schlag and Ploetzner, 2011). Overall, 133 sixth-grade students from two different middle schools participated in the study. Both groups learned from various text-picture-combinations about honeybee dances. While one group had to write a summary of what they learned, the other group took advantage of the learning strategy. Both groups worked on a pre- and a post-test. The *strategy group* (M = 13.24, SD = 3.72) outperformed the *summary group* (M = 9.75, SD = 3.68). The groups differed significantly in the overall post-test results ($F(1,130) = 24.55$, $p < .01$, $\eta^2_p = .16$), as well as on the sub-tests with respect to factual, conceptual, and transfer knowledge.

We also analyzed the worksheets from the strategy group and evaluated the quality of the markings, labels, underlines, summaries and visualizations that were produced by the students. We expected to see a positive relation between the quality of the worksheets and the post-test results: students who produced high-quality worksheets were expected to gain higher scores on the post-test. However, there was no significant correlation between the quality of the worksheets and the post-test results (r = .297, n.s.).

The study demonstrates that students who utilized the strategy learned better than the students who applied the common learning technique of writing a summary, which is often taught and used in school. In contrast to our expectations, however, no significant correlation was found between the quality of the worksheets and the post-test results. This finding indicates that the cognitive processes and externalizations produced during learning are not the same. While some students with high post-test results performed poorly on the worksheets, other students did well on the worksheets but nevertheless obtained poor results on the post-test. Thus, the students seem to apply different cognitive processes with varying quality when taking advantage of the learning strategy.

A learner’s cognitive ability is an important predictor of how they process information (e.g. Kozma and Russel, 1997). Learners with high cognitive abilities might be able to deeply process the information after being given general suggestions on how to approach the learning material. These learners might not need support to produce specific external representations in order to understand the material; it could even be that such specific guidance hinders learning (cf. the effects of scaffolding and fading; e.g. Kirkley, 2006; Quintana et al., 2006). In contrast, learners with lower cognitive abilities might not profit from general suggestions. They might require more specific guidance on how to process the material.

A second strategy focusing on internal activities rather than encouraging external activities was therefore formulated. Both strategies aim at inducing the same cognitive processes by either encouraging internal and external or only internal learning activities (see Table 2).

The *strategy that encourages internal learning activities* supports students “thinking” (e.g. selection of phrases). The *strategy that encourages internal and external learning activities* supports the same cognitive processes through external activities (e.g. underlining). The external activities should facilitate the internal information processing. Peeck (1993) assumes that instructional interventions which result in "an external and controllable product" (p.234) should be most successful.

Table 2: Two learning strategies.

cognitive processes	Learning techniques that encourage internal and external activities	Learning techniques that encourage internal activities
Selection and organization	a) *Get an overview:* Shortly read the text and look at the picture in order to get an overview.	a) *Get an overview:* Shortly read the text and look at the picture in order to get an overview.
	b) *Identify relevant aspects in the text and picture*: Underline the phrases in the text that are important to you. Search for entities in the picture that correspond to the phrases and mark them. Now label the marked entities with the underlined phrases.	b) *Identify relevant aspects in the text and picture*: Clarify the phrases in the text that are important to you. Search for entities in the picture that correspond to the phrases.
Integration and Transformation	c) *Establish relations between the text and picture:* Write a summary of what is represented on the whole in the text and picture.	c) *Establish relations between the text and picture:* What is represented on the whole in the text and picture?
	d) *Visualize important information*: Draw a sketch that illustrates which information from the text and picture is most important to you.	d) *Visualize important information*: Imagine the information from the text and picture that is most important to you.

4 STUDY

4.1 Research Question and Hypothesis

Do students with varying cognitive abilities profit differently from the two learning strategies described in Table 2? We hypothesized that students with low cognitive abilities would profit more from the strategy that encourages internal and external learning activities, whereas students with high cognitive abilities would profit more from the strategy that encourages internal learning activities.

Different forms of support might be advantageous to students with varying cognitive abilities. Students with low cognitive abilities, for example, could benefit more from the strategy with specific guidance. Such a strategy helps to orientate students by specifically instructing which activities are supposed to be carried out. In contrast, a strategy with less guidance might be more beneficial to students with high cognitive abilities. These students should be capable of independently generating the appropriate learning activities by themselves.

4.2 Method

4.2.1 Design

Two factors were varied in a 2x2-design: a) *learning strategy* (strategy that encourages internal and external learning activities vs. strategy that encourages internal learning activities) and b) *cognitive ability* (high vs. low cognitive ability).

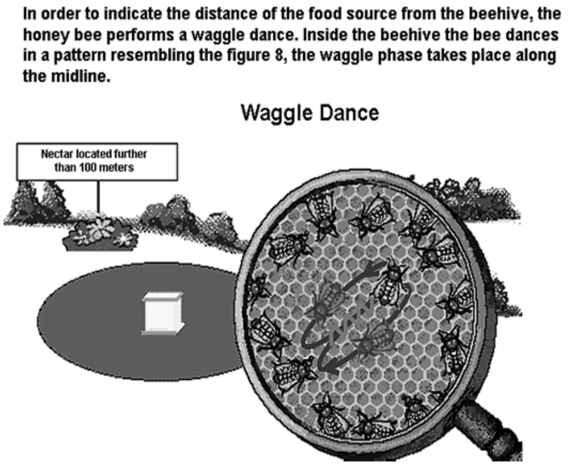
4.2.2 Participants

Overall, 24 sixth-graders (12 girls and 12 boys; mean age: 11.79, SD = .66) from three schools in South-West-Germany participated in the study. There were 4 groups, each with six students. Both sexes were evenly distributed across the groups. The students were from three different types of German secondary schools (Gymnasium, Gesamtschule, and Realschule). Participation was voluntary and participants received financial compensation.

4.3 Material

4.3.1 Learning Material

The learning material dealt with the dances of the honeybee. The students had to learn about the round dance and the waggle dance and how bees use the dances to communicate the distance of food sources (see Figure 1). The material was composed of four text-picture-combinations. The relevant information was placed in both the text and the picture so that students had to take both representations into account in order to understand the bee dances.



In order to indicate the distance of the food source from the beehive, the honey bee performs a waggle dance. Inside the beehive the bee dances in a pattern resembling the figure 8, the waggle phase takes place along the midline.

Figure 1: Example of the learning material (picture taken from Microsoft Encarta 2002; screenshot reprinted with friendly permission from the Microsoft Corporation).

4.3.2 Learning Strategies

The students in both groups were respectively given worksheets which detailed either the *strategy that encourages internal and external learning activities* or the *strategy that encourages internal learning activities* (see Table 2). The students were requested to make use of the worksheets during learning.

4.3.3 Pre- and Post-Test

In order to assess prior knowledge, participants were given a pre-test consisting of eight items. The post-test consisted of 24 items: eight on factual knowledge, which were the same as on the pre-test, eight on conceptual knowledge, and eight on transfer knowledge.

4.3.4 Assessment of Cognitive Abilities

Cognitive ability was assessed with the Mannheim Intelligence Test *MIT-KJ (*Mannheimer Intelligenztest für Kinder und Jugendliche; Conrad, Eberle, Hornke, Kierdorf and Nagel, 1976). The test measures general intelligence of children between nine and fifteen years old by assessing three verbal, one mathematical, and two visuospatial abilities. The intelligence scale ranged from one to ten points. Students scoring five points or less on the scale were assigned to the low cognitive ability group, whereas students scoring six points or more were assigned to the high cognitive ability group.

5 PROCEDURE

All students were individually assessed. They were initially tested by means of the MIT-KJ (Conrad et al., 1976) in order to assign them to the low or high cognitive ability group. The students were then randomly assigned to one of the *strategy groups*. Thereafter, all participants completed the pre-test. In order to familiarize them with the think aloud method, they took part in a training which included a practice task of 15 minutes. The students in both strategy groups received a short introduction on how to take advantage of their learning strategy. During the learning period, the students worked independently and utilized the worksheets to learn from the four text-picture-combinations about the dances of the honeybee. For each text-picture-combination, the students were given a new work-sheet. The students were requested to continuously think aloud during the learning period. Their verbalizations were recorded. The learning time was limited to 50 minutes. The students were free to finish earlier. The post-test took place after the learning phase.

6 RESULTS

6.1 Analysis of Pre- and Post-Test Results

The students answered on average 1.38 (SD = .78) of eight questions correctly on the pre-test. All four groups performed nearly the same on the pre-test (M between 1.50 and 1.33). There were no significant differences between groups on the pre-test (F(3,20) = .06, n.s.).

The learning time was on average 27.08 minutes (SD = 13.87). Students using the strategy that encourages internal and external activities learned on average longer (M = 36.71, SD = 12.14) than students using the strategy that encourages only internal learning activities (M = 18.00, SD = 8.65). Students with high cognitive abilities (M = 28.75, SD = 14.42) learned on average longer than students with low cognitive abilities (M = 25.42, SD = 13.72). The differences between groups in learning time are significant (F(1,20) = 16.67, p < .01, η^2_p = .46). The learning time, however, did not significantly correlate with the post-test results.

The post-test questions were scored by two independent raters. Interrater reliability was ICC(3, k) =

0.95. Differences in the ratings were jointly settled by the raters.

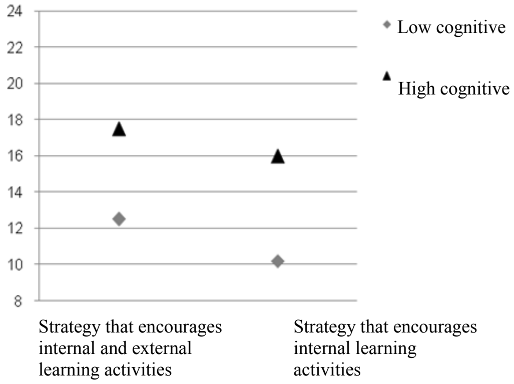


Figure 2: Overall post-test results.

The post-test results showed that the students with high cognitive abilities (M = 16.75, SD = 2.93) performed better than the students with low cognitive abilities (M = 11.33, SD = 3.11). Furthermore, students who made use of the strategy that encourages internal and external learning activities (M = 15.00, SD = 3.93) learned more than the students using the strategy that encourages only internal learning activities (M = 13.08, SD = 4.10). When the strategy groups are compared to each other at each level of cognitive ability, the students learning with the strategy that encourages internal and external learning activities outperformed the other group (see Figure 2). Similar results are found with respect to factual knowledge, conceptual knowledge, and transfer knowledge (see Table 3).

In order to determine significant differences between the groups on the post-test, a multivariate two-way analysis of variance (MANOVA) was conducted with the factor *strategy* (internal and external activities vs. internal activities) and *cognitive abilitiy* (low vs. high cognitive ability) as independent variables, and the three types of knowledge as dependent variables. The small sample sizes should be kept in mind when interpreting the data.

The analysis showed significant group differences for the factor *cognitive abilities* with respect to conceptual knowledge (F(3,20) = 14.81, p < .01, η^2_p = .42) and transfer knowledge (F(3,20) = 8.42, p < .01, η^2_p = .30). No significant differences for the factor *strategy* were found (F(3,20) = 2.48, p = .13). The effect for transfer knowledge is marginally significant (F(3,20) = 3.90, p = .06).

Table 3: The means (M) and the standard deviations (SD) on the post-test (The maximum score with respect to each type of knowledge was eight).

Strategy	which encourages internal and external learning activities				which encourages internal learning activities			
Cognitive abilities	high		low		high		low	
Type of knowledge	M	SD	M	SD	M	SD	M	SD
Factual	5.33	1.51	5.00	2.76	6.17	1.17	4.33	1.21
Concept	5.67	1.03	3.67	1.50	5.33	1.97	2.83	1.17
Transfer	6.50	1.76	3.83	2.32	4.50	.84	3.00	1.78
Overall	17.5	2.88	12.5	3.27	16.0	3.03	10.1	2.71

6.2 Analysis of the Think Aloud Protocols

In order to qualitatively determine how the students applied the strategy, the think aloud data was analyzed. The think aloud data was first transcribed and segmented into phrases. Thereafter, the phrases were associated with the corresponding learning technique. It was then analyzed to see if the technique was in fact applied. If the technique was applied, it was then judged as to whether the application took place at a surface level (e.g. selection of almost all words in the text) or at a deep level (e.g. selection of only important words in the text). All protocols were analyzed by two independent raters. Interrater reliability was ICC(3, k) = .92. Disagreements were resolved in discussion.

Deep level processing was more frequently exhibited by students with high cognitive abilities than those with low cognitive abilities. Students with low cognitive abilities processed 75% of the learning techniques at a surface level or not at all (see Table 4).

Table 4: Observed frequencies of deep and surface level processing with respect to the factors *strategy* and *cognitive abilities.*

	Strategy that encourages internal and external learning activities	Strategy that encourages internal learning activities	High cognitive ability	Low cognitive ability
Deep processing	94	39	90	43
Surface processing	90	67	70	87
No processing	8	70	32	46
Overall	192	176	192	176

Differences can also be found with respect to the strategy groups (see Table 4). The students who learned with the strategy that encourages internal and external learning activities processed more techniques at a deep level than the students who learned with the other strategy. In 40% of the cases, the students who learned with the strategy that encourages internal learning activities did not make use of any learning technique. In sharp contrast, the students who learned with the strategy that encourages internal and external learning activities almost always applied the complete strategy. Thus, promoting external learning activities seems to result in a more comprehensive use of the strategy.

At a descriptive level, the quality of the students' strategy use and the post-test results show a similar pattern. The students with high cognitive abilities outperformed the students with low cognitive abilities and the students who used the strategy that encourages internal and external learning activities learned more successfully than the students who used the strategy that encourages only internal learning activities. Furthermore, the quality of the students' strategy use correlated significantly with the post-tests results ($r = .41$, $p < .05$).

7 DISCUSSION

Two strategies for learning from texts and pictures were conceptualized and empirically evaluated in this paper. Both strategies were formed on the basis of current models of multimedia learning with the objective to foster the cognitive processes of information selection, organization, transformation, and integration.

In an experimental study, the two factors *strategy* (internal and external learning activities vs. internal learning activities) and *cognitive ability* (high vs. low) were investigated. The groups did not differ regarding age, sex, and prior knowledge. Even though the groups varied in learning time, there was no correlation between learning time and learning results. Students with high cognitive abilities performed better on the post-test than did students with low cognitive abilities. Within each ability group, students using the strategy that encourages internal and external learning activities outperformed those using the strategy that encourages internal learning activities.

In addition, the analysis of the think aloud data revealed that the quality of the students' strategy use was higher when employing the strategy that encourages internal and external learning activities. Students with high cognitive abilities, however, profited from both strategies; nevertheless, the best learning results were obtained when using the strategy that encourages internal and external learning activities. Students with low cognitive abilities, on the other hand, only learned satisfactorily when using the strategy that encourages internal and external learning activities. This strategy seems to compensate low cognitive ability, whereas the strategy that encourages internal learning activities is only advantageous under the condition of high cognitive ability.

Contrary to our expectations, the strategy that encourages internal and external learning activities did not impede the learning of students with high cognitive abilities. Even if the external activities of the students with high cognitive abilities were not more productive than those of the students with low cognitive abilities (analysis of the worksheets), the additional external activity instructions led to beneficial internal learning activities (analysis of the think aloud data). This might explain why students with high cognitive abilities also profited from the strategy that encourages internal and external learning activities.

Due to the think aloud assessment, the sample size was kept small in this study. This needs to be taken into account when interpreting the data. It was necessary, however, to acquire the process data in order to get a deeper insight into the processes that foster learning. The present study has demonstrated that the analysis of think aloud data is a promising approach to better understanding strategic information processing.

The study demonstrated that the strategy that encourages internal and external learning activities is adequate for sixth-grade students regardless of their cognitive abilities. Two other studies have demonstrated that similar strategies were also beneficial to sixth grade students learning from animation (Kombartzky et al., 2010) and text-picture-combinations (Metz and Wichert, 2009). Further research is needed to show if the proposed strategies would be advantageous for other groups of learners, as well as for other types of learning material. It would also be fruitful if future research on strategic learning would clarify the contributions of the individual learning techniques to the overall learning outcome, as well as how different combinations of learning techniques affect learning (cf. Klauer, 2010).

When thinking of learning with the computer most researchers would aspire to more complex learning environments than the text-picture-combinations described in this article. Nevertheless, many computer supported learning environments are still “just” made up of texts and pictures. Even with these “simple“ multimedia materials students need a strategy to process the information adequate. If the learning environment gets more complex, effective learning strategies become even more important. Students need to be taught how to process multimedia materials just as they are taught how to understand written text. Several studies demonstrated that strategic instructions can foster learning from multimedia (e.g. Kombartzky et al., 2010; Metz and Wichert, 2009; Schlag and Ploetzner, 2011).

When developing computerized learning environments not only usability and design aspects should be taken into account, but also strategic support which helps the learners to process the presented information effectively and effeciently. This study showed that especially techniques that encourage internal and external learning activities are beneficial for the learners. Multimedia learning environments can support the use of these learning activities by providing strategic learning prompts to the learners that are integrated into the learning environment (Ruf and Ploetzner, 2012). In particular, external learning activities can be supported by providing interactive tools that allow learners e.g. to draw sketches and to take notes.

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Evaluation of an Augmented-Reality-based 3D User Interface to Enhance the 3D-Understanding of Molecular Chemistry

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Keywords: Direct Manipulation, 3D User Interface, Augmented Chemical Reactions, Evaluation, Augmented Reality.

Abstract: The spatial understanding of chemical molecules is crucial for learning chemistry at school. With a good 3D understanding of molecules, chemical processes become obvious compared to a 2D representation in textbooks or just the molecular formula. With the increasing spread of computers, smartphones and tablets, the field of computer aided learning becomes more and more important. Common molecular viewers such as *Jmol* (Jmol, 2012) present chemical simulations as 3D renderings on a regular computer screen in combination with desktop-based user interfaces using a mouse and a keyboard to manipulate 3D molecules. Such interfaces may be cumbersome to use since users have to associate 2D mouse motion and key presses with 3D object motions. In this paper we investigate the hypothesis that the understanding of spatial structures of molecules is enhanced by Augmented-Reality-based 3D user interfaces with which students can directly manipulate the virtual 3D molecules by freely moving and rotating a 3D object in air with their hands. Our results show that a direct manipulation 3D user interface improves the 3D understanding in comparison to the traditional desktop-based user interface with mouse and keyboard.

1 INTRODUCTION

To support students learn chemistry, we have to help them understand the spatial structure of molecules. Knowing the 3D structure of molecules is important to understand the chemical behavior and properties of the molecules. Learning the 3D structure of molecules just by looking at the 2D drawings or formulas of the textbook seams not to be the best method.

Hardware representations that the students can touch have been a well-established method in chemistry education for a long time. Yet, such hardware models are not always available, and it is time consuming to build them for each student and for each molecule. Furthermore, such hardware representations are mostly not flexible or dynamic in their structure.

As computers get more powerful and mobile, interactive 3D representations of the molecules are able to provide a better way for students to inspect and understand the 3D structures. Applications can show complex molecules and animations that the students can inspect. But there is a drawback in the classical 3D presentation programs: the molecules can only be rotated and moved via the mouse and the keyboard. This indirect mapping of mouse movements to the 3D model is not always intuitive. Students have to learn the mapping of 2D mouse movements and keystrokes to 3D object manipulations involving six degrees of freedom. As a result, some of the students' focus may be diverted from the molecules to the user interface, and the structure of the molecules may not be made completely clear.

To combine the benefits of the physical molecule representations with the power of computers, there are direct manipulation 3D user interfaces which use Augmented Reality and tracked real objects to control the position and orientation of the molecules.

In this paper, we report on evaluating the Augmented Reality based 3D user interface of the Application *Augmented Chemical Reactions* (ACR) against the mouse and keyboard based user interface of the Application *Jmol* (Jmol, 2012). The evaluation took place at a secondary school with a class of 14-15 year old students of the 8th grade. In the next section, we take a look at previous work in this field and we describe both types of 3D user interfaces.

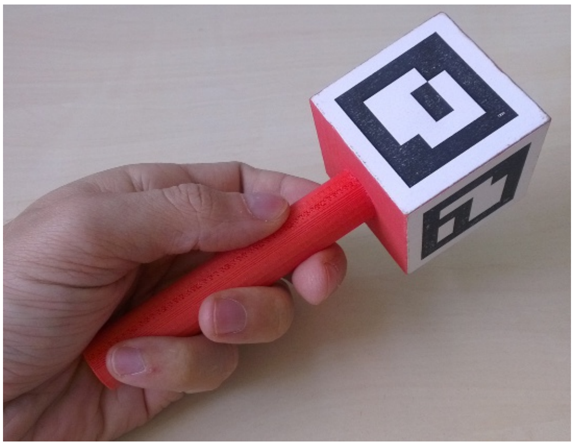


Figure 1: This device is tracked by a computer with a webcam. It is used as a 3D input device for direct manipulation.

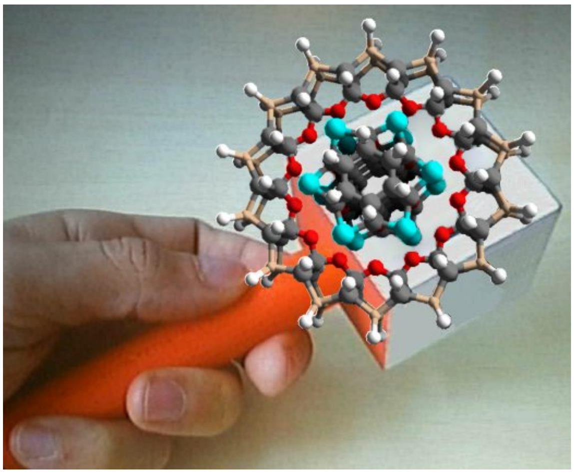


Figure 2: Augmentation of a protein molecule on top of the marker cube.

2 BACKGROUND

Many schemes to support the learning progress of students have been developed. To support the students in understanding the spatial structure of molecules, the most suitable methodologies have to be developed. A number of research efforts have shown that using physical models and therefore using direct manipulation helps students explore and understand the spatial structure of objects (Herman et al., 2006; Arnold et al., 2012; Hoyek et al., 2011). It has also been shown that a direct manipulation interface for rotation via a sensor with 3 degrees of freedom (3 DoF) yields better performance without lacking accuracy, compared to 3D rotation via a mouse (Hinckley et al., 1997). Work at the IBM Almaden Research Center investigated the user performance of different 3D input devices (Zhai, 1998).

2.1 Desktop-based user Interface with Mouse and Keyboard

There are many applications that help users understand the spatial structure and also the resulting dynamics of molecules (Panagiotopoulos et al., 2012; Johnson et al., 2011; Jmol, 2012). Yet, the commonly used user interface to rotate and move virtual objects is still a combination of mouse and keyboard (Chen et al., 1988).

2.2 3D Augmented-Reality-based user Interface

To combine the advantages of the physical direct manipulation with showing complex structures, *Augmented Chemistry* (Fjeld et al., 2007) and *Augmented Chemical Reactions* (Maier et al., 2009b) (Maier et al., 2009a) have been introduced. Both systems use Augmented Reality to deliver a direct manipulation 3D user interface to control the position and orientation of the virtual objects.

Generally speaking, Augmented Reality adds virtual information or objects interactively and in real-time to the real world, generating the impression that the added information is part of the physical world. To this end, the application *Augmented Chemical Reactions* employs a physical cube with a handle that is textured on all sides with black and white patterns (Figure 1). In a typical setup, a student holds the cube by the handle and manipulates it while sitting at a desk in front of a monitor. A webcam records the scene with the cube, and *Augmented Chemical Reactions* uses a marker tracking algorithm similar to the AR-toolkit (Kato and Billinghurst, 1998; Pustka et al., 2011) to detect and recognize the currently visible patterns on the cube. According to the size and deformation of the patterns, the algorithm calculates their position and orientation relative to the webcam – and thus the pose of the cube and handle. With this information, the virtual molecule can be drawn on top of the webcam image, leading to the illusion, that the molecule is attached to the cube (Figure 2). The virtual molecule moves in unison with the physical cube. This is a three-dimensional direct manipulation user interface.

3 EVALUATION

We conducted a user study with 14-15 year old students of a german gymnasium (secondary school) to determine whether direct manipulation of the position and orientation of virtual molecules leads to a better spatial understanding of virtual molecules than input via a standard mouse and keyboard. We selected a class in the 8th grade – just at the time when they had been taught the basic concept of what a molecule is, but they had not learned yet about the spatial structure of molecules. Therefore they were ideally suited for a study investigating which of the two user interfaces leads to a better 3D understanding of molecules.

None of them already had experience with *Augmented Chemical Reactions* or the *Jmol* application. Most of the students had lots of experience with playing 3D games, but nearly none had already used to use a 3D chemical modeling application or another 3D design application. Only one student stated to have already a good knowledge about the chemical structures of molecules. As his prior results in building the molecules were already correct, he did not have the change to improve. So this results could not be used to get a measurement of the performance of the application and thus was removed (see section 4.1).

3.1 Experimental Setup

In cooperation with a chemistry teacher, we selected ten different molecules to be inspected in this study. Those molecules were (1) Sulfur S_8, (2) Methane CH_4, (3) Ethanol C_2H_5OH, (4) Acetic acid $C_2H_4O_2$, (5) Benzene C_6H_6, (6) Hydrogen sulfide H_2S, (7) Phosphor P_4, (8) Phosphorus trifluoride PF_3, (9) Hexane C_6H_14 and (10) Carbon tetrabromide CBr_4.

We had two computer rooms, one for the *Jmol* and one for the *Augmented Chemical Reactions (ACR)* application. Each student desk was equipped with the respective computer equipment.

Computer Setup for *ACR*. The first computer room was set up to run the *ACR* application with a 3D direct manipulation user interface. Here a monitor, a keyboard, and a marker cube with a handle were placed on each student desk. A webcam on a microphone stand in shoulder height of a sitting person faced towards the student desk and the marker handle. To control the position and the orientation of the virtual molecule, the students had to hold the marker cube into the field of view of the webcam. The video stream, augmented with the currently selected molecule, was shown on the monitor in front of the student, as shown in Figure 3. The students could cycle through the set of molecules by pressing the space-bar on the keyboard.

With a well-aligned arrangement of the camera, the user, the hand-held handle and the monitor, the AR illusion via a directly manipulated physical object can be maintained with minimal strain on the hand-eye coordination. A more immersive, perfectly aligned setup can be achieved when the monitor-based arrangement is replaced with a video-see-through or optical-see-through head-mounted display. Yet, such arrangements are costly and thus currently not deployable in classrooms. For this reason, the current test setup was based on webcams and monitors on student desks.

Figure 3: Computer setup for the ACR application, using a webcam a physical cube on a handle and a monitor. The keyboard that is required to cycle through a set of molecules is not shown.

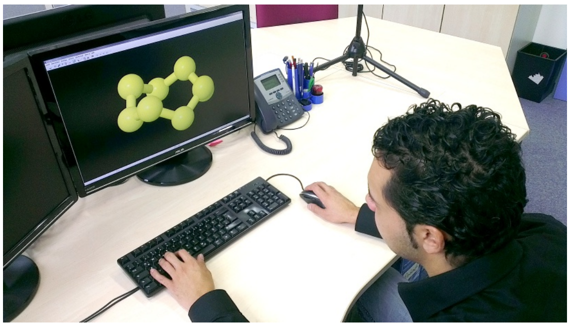
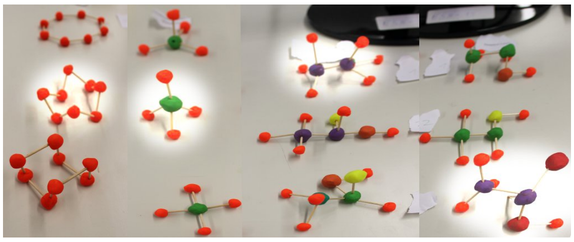
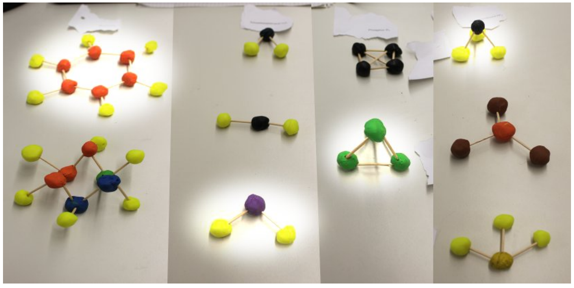


Figure 4: Typical setup to inspect and manipulate molecules on a monitor via keyboard and mouse in the *Jmol* application.

Computer Setup for *Jmol*. The second room was set up to run the *Jmol* application (Jmol, 2012), using a classical mouse and keyboard interface to manipulate virtual 3D molecular structures on the screen. To this end, a monitor, a mouse and a keyboard were placed on each student desk. When started, *Jmol* showed the first of the ten molecules, centered in the middle of the screen. By moving the mouse upwards or downwards, the molecule rotated around its horizontal axis. By moving the mouse leftwards or rightwards, the molecule rotated around its vertical axis. Schemes for translating and zooming molecules do exist in *Jmol*, but they were not required in the current setup. The students could view and explore the molecule from all sides before switching to the next



(a) Molecules #1 to #4



(b) Molecules #5 to #8

Figure 5: This is the set of versions of the first eight molecules. The correct versions are highlighted.

molecule by pressing a button in the application. Figure 4 shows the *Jmol* setup that uses the mouse and the keyboard to manipulate the position and orientation of the molecule.

Further Physical Setups for Further Student Tasks. In addition to the computer setup, the student desks carried papers and pencils and modeling clay with tooth picks. Furthermore, two to three clay models of each molecule were laid out on a table in a separate area in one of the rooms. Only one of these clay models of each molecule was correct. The other two were wrong with different degrees of spatial inappropriateness. Figure 5 shows the set of molecule versions for the first eight molecules. This is described further in task 5 of the next section.

3.2 Evaluation Design

We used a between-subjects design, consisting of two separate groups of students from the eighth grade of a secondary school. The first group, *Group ACR* consisted of 12 students, the second group, *Group Jmol* had 11 students. With the help of their teacher, the students were grouped to form a similar distribution of grades to ensure that both groups had the same knowledge.

The entire evaluation consisted of an introduction phase, five tasks including use of one of the two molecular visualization programs, and a brief subjective interview at the end.

Introduction Phase (5 minutes). At the beginning, all students were in the same room. They received an exercise sheet with printed-out molecular formulas of all ten molecules. The paper also contained a short introduction to the topic and explained what the students were asked to do in this evaluation. We additionally explained the topic and the following tasks to the students.

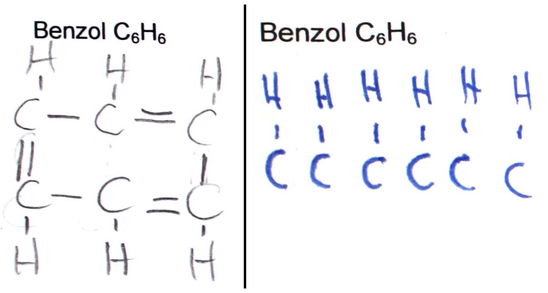


Figure 6: Example of a good and a bad drawing of the chemical formula of molecule #5 as LEWIS structure for Task 1.

Potentially confounding factors.

- The students were asked to work by themselves and not to copy from fellow students (cheat), due to the negative consequences to the evaluation. Yet, the potential for such an influence on the evaluation cannot be completely discarded.
- Since this is a between-subject design, learning effects are not crucial. For didactic reasons, we use the same, well-defined sequence through the set of molecules rather than a randomized order. If learning effects occur, they affect both conditions in a similar way and can thus be clearly identified. Yet, the test design consists of a large number of sequentially executed tasks, each involving all eight molecules, and required carry-over experiences between the tasks. Thus, learning can be seen as an omnipresent aspect over time.

Task 1: Drawings of All 10 Molecular Structures (15 minutes). As their first task, the students were asked to draw the LEWIS structure (McNaught and Wilkinson, 1997) for all molecules of the exercise sheet next to the molecular formulas – a topic that had been covered in class during the week before the evaluation. They previously were taught by their teacher how to draw this kind of structures. This should give the students a basic understanding of the connections of the atoms in the molecule. Figure 6 shows an example of a good and a bad drawing.

After this first task the students were split into the two groups and went to their respective computer rooms.

Task 2: Uninformed Modeling of All 10 Spatial Molecular Structures (20 minutes). At their desks, students were asked to build models of the ten molecular formulas with clay and toothpicks, according to

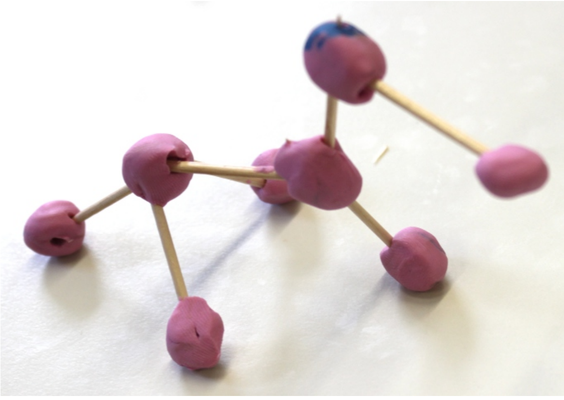


Figure 7: Model of acetic acid $C_2H_4O_2$ (molecule # 4), built by a student for Task 2. Students used modeling clay and toothpicks.

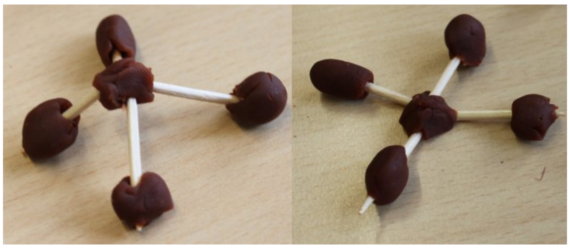
their current guess on what such a 3D structure could look like. They had not yet received any theoretical training on such 3D structures. We requested students to build these models in order to have reference data on the students' understanding of spatial molecular structures prior to using the computer-based chemical visualization applications. The students had 20 minutes to model up to 10 molecules with clay. We accepted that not everyone would complete this task. For the analysis, we therefore only took the finished models into account. Figure 7 shows a model of the fourth molecule, acetic acid ($C_2H_4O_2$), built by a student.

Task 3: Explore 3D Molecular Structures with the Respective Visualization Application (20 minutes). Each group was then asked to use their assigned visualization software to inspect all ten molecules. With *ACR*, the students sat in front of the display with the webcam above their shoulder and the marker cube in their hand. On the screen they saw the captured image plus their controlled virtual molecule rendered on top of the marker cube. The students could cycle through the set of molecules by pressing the space-bar on the keyboard. Figure 8 shows a part of the classroom with students working on the ACR version. With *Jmol*, the students used the mouse and the keyboard to rotate and move the molecules. To switch to the next molecule, they had to click a button in the software.

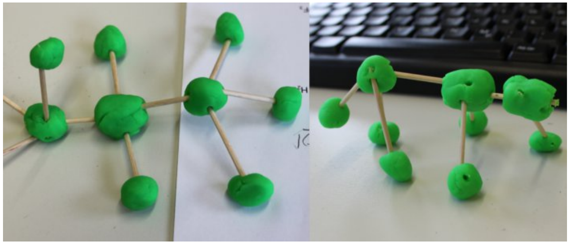
The students did not receive initial tutoring for either of the two software systems. Rather, they started immediately with the given molecular assignments. None were observed to have difficulties using the user interfaces.

The students had 20 minutes to inspect all ten molecules. After this time, the applications were stopped. In the meantime we took photos of the molecules built for Task 2.

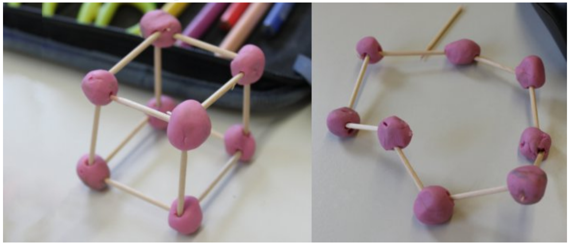
Figure 8: Classroom with students using the ACR for Task 3.



(a) worsened (Mol. #2 Methane CH_4)



(b) improved (Mol. #3 Ethanole C_2H_5OH)



(c) strongly improved (Mol. #1 Sulfur S_8)

Figure 9: Before-after state of a worsening 9(a), normal improvement 9(b) and a large improvement 9(c) (Task 4).

Task 4: Informed Modeling of All 10 Spatial Molecular Structures (10 minutes). With their new knowledge of the spatial structure of the molecules, the students were asked to improve the molecular models they had built in task 2.

To measure how the 3D understanding of the spatial structure of the molecules changed, we compared the initial version of the molecules with the new version. Figure 9 shows typical clay models before and after using the software.

Task 5: Selection between Several Pre-built Clay Models of each Molecule. To also get an objective measurement of how both 3D user interfaces improved the spatial understanding, we confronted the students with 2-3 pre-built clay models of the first eight molecular structures (see Figure 5). For the first eight molecules, we had built one clay model version that was the correct solution, one that was completely wrong and a third one that was almost correct, but still noticeably different from the correct one. Here, we could evaluate to what extent the students had gained a spatial understanding of molecular structures. Figure 5 shows the alternative clay models for the first eight molecules.

Closing Phase: Informal Interview and Questionnaire. At the end of the evaluation we had a short joint informal interview in front of the whole class. We also handed out a questionnaire to learn a bit about the students' prior knowledge. We asked the students what they liked and what they did not like. The students stated that they liked the idea of learning the molecule structure using a computer application. Especially the group using *ACR* told that they had a lot of fun using the user interface. Where the group with *Jmol* liked the general idea of using an application to show the 3D structure, the *ACR* users were fascinated about the user interface with the marker cube. All stated that they would like to continue using the application in their class to further learn about the geometry of molecules.

4 RESULTS

The evaluation consisted of two parts – the building and the improvement of the clay molecules and the selection of the right version. Table 5 at the end presents the raw absolute scores of all tasks. Empty cells denote that the students did not model the specific molecule or did not select any version in the last task.

The subsequent sections give the results, discuss these scores and suggest interpretations.

4.1 Improvements to Students' Clay Models

To measure how the AR-based and the mouse-based user interfaces of *ACR* and *Jmol* affected the spatial understanding of the virtual molecules, we compared the models built in Task 2 with the models changed in Task 4.

With the help of the chemistry teacher, we scored the molecules (Table 5). Table 1 presents the interpretation of the students' improvements from Task 2 to Task 4 – due to the use of the chemical education applications (*Jmol*, *ACR*). When the second version (Task 4) of the models was worse than the first version (Task 2), we scored this with -1 point. No improvement of the molecule was scored as 0 points, and an improvement was scored as $+1$ point. When the first version was totally wrong and the second was completely correct, we scored $+2$ points. When students already provided a perfectly correct solution in the first version (Task 2) and they did not change anything on the molecule in Task 4, we did not count it – as this does not deliver insight regarding the usefulness of the software system (user interface). The scores are presented in Table 1. A Kruskal-Wallis test shows that there is a significant difference in the medians $\chi^2(3, N = 45) = 32.34, p < 0.0001$ at a significance level of 5%. The results show that the direct manipulation 3D user interface of the *ACR* application helped the students significantly better than the

Table 1: Scores representing students' improvements between uninformed modeling of the molecules in Task 2 and informed modeling in Task 4, i.e., after having visualized the molecules with *Augmented Chemical Reactions (ACR)* or *Jmol* int Task 3.

Group 1 (ACR)								
Mol User	1	2	3	4	5	6	7	8
1	-1		1					
2		2	1			2		
3	1		1	0	0			
4	1	1	2	0	0			
5		1	1	0				
6	1	1				0		
7	1	1	1					
8	0	2	1					
9	1	0	0	1	2	0	0	0
10	1	0	0	1		0	2	0
11	2			1			2	
12	0	0	0	0			2	

Group 2 (Jmol)								
Mol User	1	2	3	4	5	6	7	8
1	2	2		0		1	0	
2	0	0				0	0	
3	0	0				0	0	
4	1	-1	1					0
5	1	-1	0					
6	2		0	0			0	
7	0				1	1	-1	2
8	1		0	0			1	
9	1		0	0			2	
10	1		0	0			2	
11	1	1	0				1	

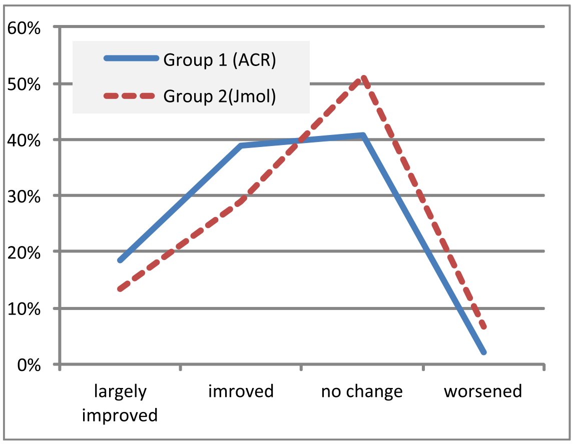


Figure 10: Percentages of the quality of the changes that students made to improve their clay models in Task 4. The height of the graph represents the percentage of the molecules which were *strongly improved*, *improved*, *no change* or *worsened*.

keyboard and mouse 3D User-Interface of *Jmol*.

Table 2 and the corresponding graph in Figure 10 show how many percent of the molecules were *strongly improved*, *improved*, *unchanged* or *worsened* by students using the *Jmol* the *ACR* program, respectively. The numbers enhance the statistical finding that Group 1 (*ACR*) using the direct manipulation 3D user interface had a significantly better improvement than Group 2 (*Jmol*) using mouse and keyboard. Both the percentages for large improvements and for normal improvements are higher for *ACR* than for *Jmol*, whereas the percentages of no change and of worsening changes are smaller. A deeper analysis of the results shows that students of group 1 (*ACR*) who were wrong in Task 2 improved more in task 4 than students of group 2 (*Jmol*). This also shows that *ACR* with the direct manipulation user interface helps more to understand the spacial structures than using an indirect manipulation user interface with mouse and keyboard (*Jmol*).

Table 2: Percentages of the quality the changes that students made to improve their clay models in Task 4.

	ACR	Jmol
Strongly improved	18%	13%
Improved	39%	29%
No change	41%	51%
Worsened	2%	7%

4.2 Students' Ability to Pick the Correct Clay Model out of a given Set of Three per Molecule

Since students' dexterous abilities may vary and the quality of some of the students' clay models may thus have depended on that, we designed Task 5 as a test that was independent of the students' own modeling skills and time limitations. We had prepared three clay model versions of the first eight molecules, with one being correct, one being slightly wrong and one being completely wrong. The students were asked to indicate for each molecule which one they considered to be the correct model. They received 2 points for the correct answer, 1 point for the nearly correct answer, and 0 points when they selected the completely wrong clay model. Although we asked the students not to copy from the others, we cannot guarantee that they did not. Table 3 summarizes the score of table 5, pertaining to Task 5.

Table 3: Scores of students' selections of three clay model versions of each molecule in Task 5.

Group 1 (ACR)								
Mol User	1	2	3	4	5	6	7	8
1	2	2	2	2	2	2	2	2
2	2	2	1	1	2	2	2	2
3	1	2	2	0	2	2	2	1
4	1	2	2	2	0	1	2	2
5	1	1	1	1	0	0	2	2
6	1	0	2	2	2	0	2	1
7	2	0	2	2	2	1	2	2
8	2	2	2	2	2	2	2	2
9	2	0	2	1	2	2	2	2
10	1	2	2	1	2	2	2	1
11	2	2	1	2	2	2	2	2
12	2	2	2	2	2	2	2	2

Group 2 (Jmol)								
Mol User	1	2	3	4	5	6	7	8
1	2	2	2	1	2	1	2	2
2	2	2	2	1	0	2	2	2
3	2	2	1	2	2	0	2	1
4	2	1	0	2	0	1	2	2
5	2	2	2	2	0	2	2	2
6	1	2	2	2	2	2	2	2
7	2	2	0	1	2	2	2	2
8	2	2	1	1	0	0	2	0
9	2	2	1	1	0	1	2	2
10	2	2	1	1	0	1	2	2
11	2	2	0	1	0	1	2	2

We calculated the average points that students achieved for each molecule. They are shown in Table 4 and in Figure 11. Interestingly, molecule #1 and #2 had a better result with the user interface of *Jmol*. The variance of these results of the group *Jmol* is unusual small in relation to the other molecules. This leads to the assumption that there was some-

Table 5: Scores of all task assignments, T1, T2, T4 and T5.

Group1(ACR)																																
User	Mol.1				Mol.2				Mol.3				Mol.4				Mol.5				Mol.6				Mol.7				Mol.8			
	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5
1	1	2	0	2	2			2	2	1	2	2	0			2	0			2	1			2				2	0			2
2	2	3	3	2	2	1	3	2	2	1	2	1	0			1	2			2	1	0	3	2	1			2	2			2
3	1	0	2	1	2	3	3	2	2	1	2	2	0	1	1	0	1	0	0	2	1	3	3	2	1			2	3			1
4	2	0	2	1	2	2	3	2	0	1	3	2	0	2	2	2	2	1	1	0	1			1	0			2	2			2
5	2			1	2	1	2	1	0	0	1	1	0	0	0	1	1			0	1			0	0			2	2			2
6	1	0	2	1	2	0	1	0	1			2				2				2	1	0	0	0	0			2				1
7	2	0	2	2	2	1	2	0	0	1	2	2	0			2	1			2	1			1	1			2	2			2
8	1	2	2	2	2	1	3	2	0	1	2	2	0			2	0			2	1			2	1			2	2			2
9	1	1	2	2	2	1	1	0	0	1	1	2	0	0	1	1		0	3	2	1	0	0	2	1	0	0	2	2	0	0	2
10	1	0	2	1	2	0	0	2	2	1	1	2	1	0	1	1	2	3	3	2	1	0	0	2	1	0	3	2	2	1	1	1
11	1	0	3	2	2	3	3	2	2			1	2	2	3	2	1			2	2	3	3	2	1	0	3	2	2			2
12	1	0	0	2	2	0	0	2	2	0	0	2	2	0	0	2	1			2	1			2	1	0	3	2	2			2

Group2(Jmol)																																
User	Mol.1				Mol.2				Mol.3				Mol.4				Mol.5				Mol.6				Mol.7				Mol.8			
	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5	T1	T2	T4	T5
1	1	1	3	2	2	1	3	2	2			2	0	0	0	1	0			2	1	0	1	1	1	0	0	2	2	3	3	2
2	1	1	1	2	2	1	1	2	2			2	0			1				0	1	0	0	2	1	1	1	2	2			2
3	1	1	1	2	2	1	1	2	2			1	0			2	0			2	1	0	0	0	1	1	1	2	2			1
4	2	0	2	2	2	3	1	1	0	1	2	0	0			2				0	1	3	3	1	0			2	2	1	1	2
5	0	0	2	2	2	2	0	2	0	1	1	2	0			2	0			0	1	3	3	2	0			2	2			2
6	1	0	3	1	2	3	3	2	2	2	2	2	2	2	2	2	2			2	1	3	3	2	1	2	2	2	2			2
7	2	0	0	2	2	3	3	2	2			0	2			1	0	2	3	2	1	1	2	2	1	1	0	2	2	1	3	2
8	1	0	2	2	2	3	3	2	2	1	1	1	2	1	1	1	2			0	1			0	1	1	2	2	2			0
9	1	0	2	2	2	3	3	2	2	1	1	1	2	1	1	1	2			0	1	3	3	1	1	0	3	2	2			2
10	1	0	2	2	2	3	3	2	2	1	1	1	2	1	1	1	2			0	1	3	3	1	1	0	3	2	2			2
11	1	0	2	2	2	2	3	2	2	2	2	0	1			1	2			0	1	3	3	1	1	1	2	2	2	1	1	2

Table 4: Average number of points students achieved for each molecule in Task 5.

	ACR	Jmol
1	1.58	1.91
2	1.42	1.91
3	1.75	1.09
4	1.50	1.36
5	1.67	0.73
6	1.50	1.18
7	2.00	2.00
8	1.75	1.73

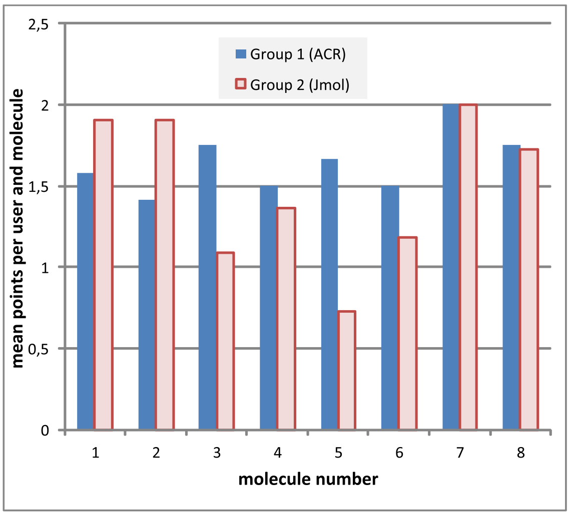


Figure 11: This diagram shows the mean points users had for each molecule with Task 5 (Selecting the right version of the molecules).

thing unintended going on (copying from others). Molecule #1 with its crown-like structure can be seen in Figure 11. Molecule #2 has a simple tetrahedron structure with the carbon atom in the middle. For molecules #3, #4, #5, and #6, group *ACR* was better than group *Jmol*, while molecules #7 and #8 faired approximately even in both groups. The large difference in the results of Molecule #5 could be explained in the following way: Students using the *Jmol* application could not remember the flat structure of the molecule anymore, so they probably took the more complex looking structure, whereas the students with the *ACR* could have remembered the flat structure. Molecule #7 and #8 were so easy that nearly everyone has picked the right version.

On average across all molecules, students of group *ACR* achieved 13.17 points, compared to 11.91 of group *Jmol*.

5 DISCUSSION AND CONCLUSIONS

Although the time for using the software was not very long, there is already a significant difference in the improvement of the spatial understanding of the 3D molecules. We think that by using a direct manipulation 3D user interface, students can literally grasp the spatial structure. Whereas with mouse and keyboard, there is a mapping of the movements (2D horizontal movement of the mouse on the table results in a rotation of the virtual molecule on the screen). With this mapping, it seems to be not so easy to concentrate on the spatial structure of the virtual molecules. People are used to direct manipulation from their childhood.

Consequently this user interface is more natural and supports the learning of the spatial structures.

All students also mentioned that they had fun using the application and would like to use it more often in class. Fun is also one of the most important enablers in learning.

Our evaluation showed that this assumption seems to be valid. Further investigations with a longer period of the study could investigate this finding in more detail.

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Effects of Mid-term Student Evaluations of Teaching as Measured by End-of-Term Evaluations

An Emperical Study of Course Evaluations

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Abstract: Universities have varying policies on how and when to perform student evaluations of courses and teachers. More empirical evidence of the consequences of such policies on quality enhancement of teaching and learning is needed. A study (35 courses at the Technical University of Denmark) was performed to illustrate the effects caused by different handling of mid-term course evaluations on student's satisfaction as measured by end-of-term evaluations. Midterm and end-of-term course evaluations were carried out in all courses. Half of the courses were allowed access to the midterm results. The evaluations generally showed positive improvements over the semester for courses with access, and negative improvements for those without access. Improvements related to: Student learning, student satisfaction, teaching activities, and communication showed statistically significant average differences of 0.1-0.2 points between the two groups. These differences are relatively large compared to the standard deviation of the scores when student effect is removed (approximately 0.7). We conclude that university policies on course evaluations seem to have an impact on the development of the teaching and learning quality as perceived by the students and discuss the findings.

1 INTRODUCTION

For decades, educational researchers and university teachers have discussed the usefulness of, as well as the best practice for student evaluations of teaching (SET). To a large extent discussions have focused on summative purposes like the use of SETs for personnel decisions as recruitment and promotion (Oliver and Sautter 2005; McKeachie, 1997; Yao and Grady, 2005). The focus in the present study is the formative aspect, i.e. the use of SETs to improve the quality of teaching and learning.

Much effort has been put into investigating if SETs give valid measurements of teaching effectiveness with students' learning outcome as the generally accepted – though complex to measure – core factor (see metastudies of Wachtel, 1998, and Clayson, 2009). Though SETs can be questioned to be the best method for measuring teaching effectiveness (Yao and Grady, 2005), there is a general agreement that it is the most practical and to some extent valid measure of teaching effectiveness (Wachtel, 1998). Additionally, SETs provide important evidence that can be used for formative purposes (Richardson, 2005).

Studies of the long-term effect of SETs tend to lead to the discouraging conclusion that no general improvement takes place over a period of 3-4 years or more (Kember et.al., 2002; Marsh and Hocevar, 1991). However, it is generally found that when the feedback from SETs is supported by other steps, such as consultations with colleagues or staff developers, or by a strategic and systematic approach to quality development at university level, improvements can be found according to the SET results (Penny and Coe, 2004; Edström, 2008).

Some attention has also been directed to the timing of the evaluations – midterm, end-of-term, before or after the exam (Wachtel, 1998). There is some evidence that evaluation results depend on whether they were gathered during the course term or after course completion (Clayson, 2009; Richardson, 2005).

Keeping the formative aim in mind, it is of interest whether midterm evaluations can lead to improvement within the semester to meet the needs of the students in a specific class context (Cook-Sather, 2009). In a meta-analysis of a number of studies comparing midterm and end-of-term SET results, Cohen (1980) concluded that on average the mid-term evaluations had made a modest but significant contribution to the improvement of teaching. His analysis confirms findings from other studies that the positive effect is related to augmentations of the feedback from students – typically consultations with experts in teaching and learning (Richardson, 2005; Penny and Coe, 2004).

In Denmark as in other Nordic countries, the general use of course evaluations has a shorter history. SETs have primarily been introduced for formative purposes as well as an instrument for the institution to monitor and react on student satisfaction in general and on specific issues (e.g. teachers' English proficiency). As an effect of a requirement from 2003, all Danish universities make the outcome of course evaluations public (Andersen et al., 2009). Thus, key results of the existing SET processes are also used to provide information to students prior to course selections.

At the Technical University of Denmark, average ratings of answers to closed questions related to the course in general are published on the university's web site. Ratings of questions related to individual teachers and answers to open questions are not published. The outcome is subject to review in the department study board that may initiate follow-up actions.

As an extensive amount of time and effort is spent on the evaluation processes described, it is of vital interest to examine whether the processes could be improved to generate more quality enhancement. Therefore, the present study provides a basis to consider whether mid-term course evaluations can be used as a supplement to (or partial substitution of) end-of-term evaluations to create an immediate effect on quality of teaching and learning in the ongoing course.

In the study, the student evaluations are treated as a source of information on the teaching and learning process, as perceived by the students, which can be used as a basis for improvements. An experimental setup is designed to address the question: What is the effect of mid-term course evaluations on student's satisfaction with the course as measured by end-of-term evaluations?

The study addresses how general university policies can influence the quality of courses by deciding when to perform student evaluations. Therefore, the course teachers were not obliged to take specific actions based on the midterm evaluations.

The paper is organized as follows. The experimental design is explained in Section 1. Section 2 gives the methods of analysis, and Section 3 the results. Section 4 discusses the findings, and we conclude in Section 5.

2 EXPERIMENTAL DESIGN

Since 2001 standard student evaluations at the Technical University of Denmark are performed using an online questionnaire posted on "CampusNet" (the university intra-net) as an end-of-term evaluation in the last week of the semester (before the exams and the grades are given). The semesters last thirteen weeks. On one form the student is asked questions related to the course in general (Form A) and on another form questions related to the individual teacher (Form B). The questions can be seen in Table 1. The students rate the questions on a 5 point Likert scale (Likert, 1932) from 5 to 1, where 5 corresponds to the student "strongly agreeing" with the statement and 1 corresponds to the student "strongly disagreeing" with the statement. For questions A.1.6 and A.1.7, a 5 corresponds to "too high" and 1 to "too low". In a sense for these two questions a 3 corresponds to satisfactory and anything else (higher or lower) corresponds to less satisfactory. Therefore the two variables corresponding to A.1.6 and A.1.7 were transformed, namely: 5-abs(2x-6). Then a value of 5 means "satisfactory" and anything less means "less satisfactory". Furthermore, the evaluations contain three open standard questions "What went well – and why?", "What did not go so well – and why?", and "What changes would you suggest for the next time the course is offered?" Response rates are typically not quite satisfactory (a weighted average of 50%). However, they correspond to the typical response rates for standard course evaluations. The results are anonymous when presented to teachers while they in this study were linked to encrypted keys in order to connect a student's ratings from midterm to end-of-term.

A study was conducted during the fall semester of 2010 and included 35 courses. An extra midterm evaluation was setup for all courses in the 6th week of the semester. The midterm evaluations were identical to the end-of-term evaluations. The end-of-term evaluations were conducted as usual in the 13th week of the semester. The criteria for choosing

Table 1: The evaluation questions.

Id no.	Question	Short version of question (for reference)
A.1.1	I think I am learning a lot in this course	Learning a lot
A.1.2	I think the teaching method encourages my active participation	TM activates
A.1.3	I think the teaching material is good	Material
A.1.4	I think that throughout the course, the teacher has clearly communicated to me where I stand academically	Feedback
A.1.5	I think the teacher creates good continuity between the different teaching activities	TAs continuity
A.1.6	5 points is equivalent to 9 hours per week. I think my performance during the course is	Work load
A.1.7	I think the course description's prerequisites are	Prerequisites
A.1.8	In general, I think this is a good course	General
B.1.1	I think that the teacher gives me a good grasp of the academic content of the course	Good grasp
B.1.2	I think the teacher is good at communicating the subject	Communication
B.1.3	I think the teacher motivates us to actively follow the class	Motivate activity
B.2.1	I think that I generally understand what I am to do in our practical assignments/lab courses/group computation/group work/project work	Instructions
B.2.2	I think the teacher is good at helping me understand the academic content	Understanding
B.2.3	I think the teacher gives me useful feedback on my work	Feedback
B.3.1	I think the teacher's communication skills in English are good	English/English skills

courses were that:

1. The expected number of students for the course should be more than 50
2. There should be only one main teacher in the course
3. The course should not be subject to other teaching and learning interventions (which often imply additional evaluations)

The courses were randomly split into two groups: one half where the teacher had access to the results of the midterm evaluations (both ratings and qualitative answers to open questions) and another half where that was not the case (the control group). The courses were split such that equal proportions of courses within each Department were assigned to the two groups. The distribution of responses in the two groups is given in Table 2. Furthermore the number of students responding at the midterm and final evaluations and the number of students who replied both evaluations are listed. For each question the number of observations can vary slightly caused by students who neglected to respond to one or more questions in a questionnaire.

The majority of the courses were introductory (at Bachelor level), but also a few Master's courses were included. The courses were taken from six different Departments: Chemistry, Mechanics, Electronics, Mathematics, Physics, and Informatics.

Table 2: The two groups in the experiment.

Access to midterm evaluations	Number of courses	No. of matched responses	Percentage of responses
Yes	17	687	53
No	18	602	46.7

No further instructions were made to the teachers on how to utilize the evaluations in their teachings.

3 METHOD

It has been disputed whether, and to what extent, SET ratings are influenced by extraneous factors (Marsh, 1987; Cohen, 1981). In the present study it is taken into consideration that student evaluations may be biased, e.g. by different individual reactions to the level of grading or varying prior subject interest (Wachtel, 1998; Richardson, 2005), or as a result of systematic factors related to the course such as class size or elective vs. compulsory (McKeachie, 1997; Wachtel, 1998; Alamoni, 1999). In order to test the differences between midterm and final evaluations as well as differences between with/without access to midterm evaluations while removing factors like students' expected grade (Wachtel, 1998; Clayson, 2009) or high/low rated courses, we performed two kinds of tests.

a) Paired t-tests where a student from midterm to the final evaluation is a paired observation and we test the null-hypothesis that there is no difference between midterm and final evaluations (Johnson et al., 2011).

b) t-tests for the null-hypothesis that there is no difference between having access to the midterm evaluations and not (Johnson et al., 2011).

These tests were based on differences in evaluations for the same student in the same course from midterm to end-of-term evaluation in order to remove course, teacher, and individual factors. In Table the number of students who answered both midterm and final evaluations are referred to as the number of matches.

4 RESULTS

Pairwise t-tests were conducted for the null-hypothesis that the mean of the midterm evaluations were equal to the mean of the end-of-term evaluations for each question related to either the course or the course teacher. The results are summarized in Table 3 and Table 4 for the courses where the teacher had access to the midterm evaluation results and those who had not, respectively.

Table 3: Summary of pairwise t-tests between midterm and end-of-term course and teacher evaluations. For courses without access to the evaluations.

Final-midterm	Mean difference (std)	p-value	p-value < 0.05
A.1.1 (Learning a lot)	-0.056 (0.96)	0.17	No
A.1.2 (TM activates)	-0.053 (0.98)	0.21	No
A.1.3 (Material)	-0.065 (1.0)	0.13	No
A.1.4 (Feedback)	0.081 (1.1)	0.085	No
A.1.5 (TAs continuity)	-0.075 (1.0)	0.095	No
A.1.6 (Work load)	-0.040 (0.15)	0.53	No
A.1.7 (Prerequisites)	-0.049 (1.2)	0.32	No
A.1.8 (General)	**-0.12 (0.97)**	**0.0038**	**Yes**
B.1.1 (Good grasp)	-0.044 (0.86)	0.23	No
B.1.2 (Communication)	-0.066 (0.84)	0.068	No
B.1.3 (Motivate activity)	-0.035 (0.90)	0.36	No
B.2.1 (Instructions)	-0.048 (0.99)	0.33	No
B.2.2 (Understanding)	-0.012 (0.85)	0.78	No
B.2.3 (Feedback)	-0.015 (0.97)	0.76	No
B.3.1 (English)	-0.046 (0.79)	0.54	No

Table 4: Summary of pairwise t-tests between midterm and end-of-term course and teacher evaluations. For courses with access to the evaluations.

Final-midterm	Mean difference (std)	p-value	p-value < 0.05
A.1.1 (Learning a lot)	**0.089 (0.77)**	**0.0040**	**Yes**
A.1.2 (TM activates)	0.048 (0.93)	0.20	No
A.1.3 (Material)	0.019 (0.88)	0.59	No
A.1.4 (Feedback)	**0.18 (1.0)**	**<0.0001**	**Yes**
A.1.5 (TAs continuity)	0.039 (0.92)	0.29	No
A.1.6 (Work load)	0.058 (1.4)	0.30	No
A.1.7 (Prerequisites)	0.053 (0.93)	0.16	No
A.1.8 (General)	0.039 (0.85)	0.26	No
B.1.1 (Good grasp)	0.020 (0.78)	0.50	No
B.1.2 (Communication)	0.039 (0.74)	0.15	No
B.1.3 (Motivate activity)	0.016 (0.89)	0.64	No
B.2.1 (Instructions)	-0.038 (0.94)	0.36	No
B.2.2 (Understanding)	0 (0.89)	1.0	No
B.2.3 (Feedback)	0.059 (1.0)	0.20	No
B.3.1 (English)	-0.071 (0.73)	0.13	No

For the courses without access to the midterm evaluations the general trend is that the evaluations are better at midterm than at end-of-term. This is seen as the mean value of the midterm evaluations subtracted from the final evaluations are negative for most questions. In contradiction, the courses with access to the midterm evaluations have a trend towards better evaluations at the end-of-term, i.e. the means of the differences are positive. The question related to the general satisfaction of the course (A.1.8) got significantly lower evaluations at end-of-term when the teacher did not have access to the midterm evaluations ($p = 0.0038$). The question related to the academic feedback throughout the course (A.1.4) got significantly higher scores at the end-of-term when the teacher had access to the midterm evaluations ($p < 0.0001$). The question related to whether the student felt he/she learned a lot (A.1.1) got significantly higher evaluations at end-of-term when the teacher had access to the midterm evaluations ($p = 0.0040$). The increase or decrease in student evaluations were of average values in the range [-0.12,0.18]), and significant changes were of average absolute values [0.089; 0.18], (A.1.1 with access being the lowest and A.1.4 with access being the highest). The size of the (dis)improvement should be compared with the standard deviations of the differences divided by the squareroot of two (approximately 0.7), which is the standard deviation of the scores where the student effect has been removed.

For the last analysis the midterm evaluations were subtracted from the end-of-term evaluations for each student and each course. The two groups with/without access to midterm evaluations were then compared based on these differences using a two sample t-test for differences between means; the results are summarized in Table 5.

Table 5: Summary of t-tests of the null-hypothesis that there is no difference in the evaluation differences from midterm to end-of-term between courses with and without access to the midterm evaluations. A folded F-test was used to test if the variances of the two groups were equal. If so, a pooled t-test was used, otherwise the Satterthwaite's test was used to check for equal means.

With-without access	Mean difference	p-value	Significant (p-value < 0.05)
A.1.1 (Learning a lot)	**0.15**	**0.0045**	**Yes**
A.1.2 (TM activates)	0.10	0.071	No
A.1.3 (Material)	0.084	0.13	No
A.1.4 (Feedback)	0.099	0.11	No
A.1.5 (TAs continuity)	**0.11**	**0.05**	**Yes**
A.1.6 (Work load)	0.098	0.24	No
A.1.7 (Prerequisites)	-0.0037	0.95	No
A.1.8 (General)	**0.16**	**0.0032**	**Yes**
B.1.1 (Good grasp)	0.064	0.18	No
B.1.2 (Communication)	**0.11**	**0.021**	**Yes**
B.1.3 (Motivate activity)	0.051	0.32	No
B.2.1 (Instructions)	0.0095	0.88	No
B.2.2 (Understanding)	0.012	0.84	No
B.2.3 (Feedback)	0.073	0.27	No
B.3.1 (English skills)	-0.025	0.77	No

The general trend is that the courses where the teacher had access to the midterm evaluation results get a larger improvement in evaluations at the end-of-term than those where the teachers did not have that access (the differences are positive). The only exceptions to this trend are found in two questions regarding factors that cannot be changed during the course (course description of prerequisites (A.1.7) and teacher's English skills (B.3.1)). However, these are not significant. The questions related to the student statements about learning a lot, the continuity of the teaching activities, the general satisfaction with the course, and the teacher's ability to communicate the subject (A.1.1, A.1.5, A.1.8, and B.1.2) had significantly higher increases from midterm to end-of-term when the teachers had access to the midterm evaluations, compared to the courses where the teachers did not have access. Note that the significant differences in means for the questions are of sizes in the range [0.11, 0.16].

According to subsequent interviews (made by phone), the percentage of the courses with access to the midterm evaluations where the teachers say they shared midterm evaluations with students was 53%, and the percentage of courses where the teachers say they made changes according to the midterm evaluations was 53%. The percentage of the courses with access to the midterm evaluations where the teachers say they either shared the evaluations, made changes in the course, or both was 71%.

5 DISCUSSION

The results illustrate that students are generally more satisfied with their courses and teachers at end-of-term when midterm evaluations are performed during the course and teachers are informed about the results of the evaluations.

According to the evaluations, students perceive that courses improve when midterm evaluations are performed and the evaluations and the teachers are informed. Though the teachers were not instructed how to react on the results from the mid-term evaluation, it turned out that almost ¾ of the teachers followed up on the evaluations by sharing the results with their students and/or making changes in the course for the remaining part of the semester. The fact that ¼ of the teachers acted like the group who were not allowed access to the midterm results could cause the effects to be even smaller than if all teachers acted. The effects are relatively large when compared to the standard deviation of the scores where the student effect has been removed: approximately 0.7.

We expect that the actions upon the midterm evaluations of the ¾ in many cases have included elaborated student feedback to the teacher, a dialogue about possible improvements, and various interventions in the ongoing teaching and learning activities, which can explain the increased satisfaction as expressed in the end-of-term evaluation. For this to happen, the teachers should both be motivated and able to make relevant adjustments (Yao and Grady, 2005). The ability to make relevant adjustments will usually increase as a result of participation in teacher training programs that will also encourage teachers to involve both students and peers in teaching development activities. However, less than half of the teachers responsible for the courses in this study have participated in formal University teacher training programs. The proportion of the teachers who have participated in training programs is the same for both groups of courses (35 % and 38 %, respectively). Therefore, the observed effect of the mid-term evaluation does not seem to be directly dependent of whether the teacher has participated in formal teacher training.

For future work it would be of interest to directly measure the placebo effect of conducting midterm evaluations as opposed to also measuring the effect of real improvement.

From the student comments in the evaluation forms we noticed that there in some courses was a development pointed out. As an example one student writes at midterm that: “A has a bad attitude; Talking down to you when assisting in group work”. At end-of-term the student writes: “In the beginning of the course A’s attitude was bad – but here in the end I can’t put a finger on it”. Such a development was found in courses with access to the midterm evaluations and where the instructor said he/she made changes according to the evaluations. This illustrates the usefulness of midterm evaluations when addressing students evaluations within a semester.

In most of the courses the major points of praise and criticism made by the students are reflected both at midterm and end-of-term. Examples are: That the course book is poor, the teaching assistants don’t speak Danish, the lecturer is good etc. Thus such points which are easily changed from semester to semester rather than within a semester are raised both from midterm and end-of-term evaluations.

Various studies show that mid-term evaluations may change the attitudes of students towards the teaching and learning process, and their communication with the teacher, especially if the students are involved actively in the process e.g. as consultants for the teachers (Cook-Sather, 2009, Fisher and Miller, 2008; Aultman, 2006; Keutzer, 1993) – and it may even affect the students’ subsequent study approaches and achievements (Greenwald and Gilmore, 1997, Richardson 2005). Such effects may also contribute to the improved end-of-term rating in the cases where teachers with access to the mid-term evaluation results share them with their students.

There is evidence that SETs in general do not lead to improved teaching as perceived by the students (Marsh, 1987) and one specific study quoted by Wachtel (1998) of faculty reactions to mandatory SETs indicate that only a minority of the teachers report making changes based on the evaluation results.

However, the present study indicates that mid-term evaluations (as opposed to end-of-term evaluations) may provide a valuable basis for adjustments of the teaching and learning in the course being evaluated.

As the course teachers were not obliged to take specific actions based on the mid-term evaluations, the study gives a good illustration of how the university policies can influence the courses by deciding when to perform student evaluations.

It seems to be preferable to conduct midterm evaluations if one is concerned with an improvement of the courses over a semester (as measured by student evaluations).

One may argue that both a midterm and an end-of-term evaluation should be conducted. However, it is a general experience that response rates decrease when students are asked to fill in questionnaires more frequently. If this is a concern, it could - based on the results of this study - be suggested to use a midterm evaluation to facilitate improved courses and student satisfaction.

On the other hand, it is widely appreciated that the assessment of students’ learning outcome should be aligned with the intended learning outcomes and teaching activities (TLAs) of a course in order to obtain constructive alignment (Biggs and Tang, 2007). Therefore, to obtain student feedback on the entire teaching and learning process, including the alignment of assessment with objectives and TLAs, an end-of-term student evaluation should be performed after the final exams where all assessment tasks have been conducted (Edström, 2008). In this case, teachers can make interventions according to the feedback only for next semester’s course. This approach does not facilitate an improvement in courses according to the specific students taking the course a given semester.

Based on the results of the present study it could be suggested to introduce a general midterm evaluation as a standard questionnaire that focuses on the formative aspect, i.e. with a limited number of questions concerning issues related to the teaching and learning process that can be changed during the semester. It should conform to the existing practice of end-of-term evaluations by including open questions and making it possible for the teacher to add questions – e.g. inviting the students to note questions about the course content that can immediately be addressed in the teaching. This can serve as a catalyst for improved communication between students and teacher (Aultman, 2006).

As a consequence, the standard end-of-term questionnaire could be reduced and focus on general questions (like A.1.4, A.1.8. and B.1.1, see Table 1) and matters that are left out in the mid-term evaluation (e.g. teachers proficiency in English, B.3.1). Besides, it could be considered to encourage the teachers to use different kinds of consultations by faculty developers and/or peers to interpret the student feedback (ratings and comments) and discuss relevant measures to take (Penny and Coe, 2004).

The present study considered improvements over one semester as measured by end-of-term student evaluations as opposed to long-term improvements as well as studies including interviews with instructors and students. These limitations were discussed in more detail in the introduction of this paper.

6 CONCLUSIONS

An empirical study conducting midterm as well as end-of-term student evaluations in 35 courses at the Technical University of Denmark was carried out in the fall of 2010. In half of the courses the teachers were allowed access to the midterm evaluations, and the other half (the control group) was not. The general trend observed was that courses where teachers had access to the midterm evaluations got improved evaluations at end-of-term compared to the midterm evaluations, whereas the control group decreased in ratings. In particular, questions related to the student feeling that he/she learned a lot, a general satisfaction with the course, a good continuity of the teaching activities, and the teacher being good at communicating the subject show statistically significant differences in changes of evaluations from midterm to end-of-semester between the two groups. The changes are of a size 0.1-0.2 which is relatively large compared to the standard deviation of the scores where the student effect is removed of approximately 0.7.

If university leaders are to choose university- or department-wise evaluation strategies, it is worth considering midterm evaluations to facilitate improvements of ongoing courses as measured by student ratings.

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Understanding the Challenges of Introducing Self-driven Blended Learning in a Restrictive Ecosystem

Step 1 for Change Management: Understanding Student Motivation

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Abstract: This paper describes the implementation of a prototype for blended learning in a Software Engineering course at the Cooperative State University Baden-Württemberg in Karlsruhe. The University has certain particularities that distinguish it from other Universities because students alternate quarters between study and work. Thus, students receive a salary during their three years towards earning a Bachelor Degree and attendance is mandatory. In cohorts, around 30 students spend an average day with at least 5 hours of frontal lecture in the same classroom. Software Engineering takes up about 5 hours a week of in-class time in their second year of study and is the first course students have seen with a self-driven, blended learning format. The paper describes the set-up of the learning environment based on known research results of motivational factors. Based on an exploratory survey of 59 students, these motivation factors are compared to students' motivations and their realizations in traditional and self-driven lecture format. Answers revealed that change presents a major challenge for most students and identifies the need for explicit habit building, change management and improved serving of students' basic needs in a grade-based ecosystem.

1 INTRODUCTION

In this paper, an approach to self-driven blended learning is adopted with a group of 90 students in their second year (out of three) during their Bachelor program at the Cooperative State University Baden-Württemberg in Karlsruhe, Germany. In this setting, the academic year is based on a Quarter system. Students spend alternating quarters studying or working, earning a salary throughout the year. Their attendance at University is mandatory and they study in cohorts of around thirty students. As students are required to remain within their cohort in order to graduate, failing a course results in the failure of the entire Bachelor degree. As a result of this set-up, students spend more than 5 hours a day and sometimes up to 25 hours per week in frontal lectures in a single classroom. 15 minute breaks mornings and afternoons and a lunch break in the middle of the day round up the program. Evenings and weekends are spent with learning the material. Some full-time lecturers can teach over 20 hours a week, including courses outside of their immediate expertise. Other lecturers teach on the side while working in industry. Both students and lecturers work under intense time and performance pressures.

Students have never before been responsible for their own learning beyond what is needed to perform well on an exam in a traditional setting. Neither in school nor at the University has self-regulated learning been explored. However, there are necessary reasons for changing the learning environment away from the frontal lecture from employers', students' and University points of view.

From the employer point of view, it is important to move students from a check-box based approach to obtaining good grades to a mastery based approach, which is more aligned with workplace demands. Whereas in school, handing in something to be graded on a certain date may count as a completed task, industry work environment expects several passes through a piece of work until perfected. While one might think that behaviour can be adapted based on environment, employers report that key reasons for not hiring students include their lack of transfer skills, lack of critical reflection on own performance and lack of soft-skills (Heidenreich, 2011).

From the student point of view, reasons for changing the format of coursework are threefold: First, the number of hours spent listening to lectures can be decreased by letting students work independently towards pre-defined goals, thereby becoming more actively involved in the learning process. Then, with up to 25 weekly hours of frontal lecture, this format may be perceived as a nice change of pace. Finally, due to the noticeable difference in know-how between students and even between lecturer and student in the case of current industry standards, there is an advantage to leaving space to learn from other students in the small-class setting.

The University's reasons include knowledge of research results about positive learning outcomes when creating a more active and problem based learning environment (Garrison and Kanuka 2004; Goel and Sharda, 2004) despite the fear of change (Hall et al., 2002). Key reasons for change include the overwhelming variety of high-quality information sources that are available on the web. With the most current appearance of MOOCs (Massively Open Online Courses) from some of the top Universities in the US, standards for frontal lectures are set, including written transcripts of what was said, the ability to rewind and re-listen to any lecture any time and communicating with an active global community. Increasingly, excellent information is available via Youtube and Internet outside of any systematic courses as students are relying less and less on books to acquire knowledge in the field of Information Technology.

The goal of this exploratory study and corresponding survey is to understand student motivation in the example of a restrictive environment, where grades and efficiency are central to survival. A gap in research on this topic has been noted the literature (Shea Bidjerano, 2010). Software Engineering was chosen as the first class to move towards self-driven learning for three reasons: 1. many hours are available for a reasonable amount of material so there is room for slow buy-in, 2. high-quality information is available online for this topic, 3. large differences in student know-how, ranging from expert to novice based on their work experience, 4. the subject is very applied and matches closely with most students' reality at work. Students experienced the new set up and were asked to respond to an initial exploratory survey that revealed a surprising and much deeper complexity of the issues involved in this change. Section 2 will summarize the theoretical foundations of the didactic set-up for this approach. Section 3 will describe the experience from the teacher point of view. Section 4 and 5 will evaluate qualitative and quantitative results from an exploratory survey taken at the end of the second month out of the 11-week long course in order to understand how student motivation corresponds with inbuilt motivators for the new format. Section 6 will conclude by discussing mismatches in motivation and proposing concrete steps to manage change and build habits.

2 THEORETICAL FOUNDATION

The software engineering course was redesigned around motivators with content and platforms aligned as shown to be important (Derntl and Motschnig-Pitrik, 2005). This section discusses the theoretical foundation behind the motivators, the content design and platform requirements.

2.1 Motivators

Despite some controversy as to the exact definition of extrinsic and intrinsic motivators (Rheinberg, 2006), we will distinguish internal drivers such as autonomy, purpose, and mastery from external drivers, a number of chosen mechanics from gamification that have been shown as effective in real world systems with academic research still forthcoming in this emerging field.

2.1.1 Intrinsic Motivation

According to positive psychology's theories about motivation (Pink, 2010; Deci, 2012; Scott Rigby et al., 1992; Seligman and Csikszentmihalzi, 2000; Kearsley, 2000; Gagné and Deci, 2005), humans are motivated to work on cognitively difficult tasks when they are granted autonomy, purpose and mastery. Accordingly, the course was designed to grant students *autonomy* by allowing choice of speed and order for studying six out of nine topics of their choice (see 2.3) with enough time to obtain *mastery*. The *purpose* was given because the acquired knowledge would make students more powerful partners in project work for the coming quarter and because the material is immediately useful at their workplace as software engineers in training.

2.1.2 Extrinsic Motivation

Gamification is a controversial topic that has become ubiquitous in the business world since 2010 when the term was coined by the gamification community (Zicherman and Linder, 2010; McGonigal, 2012). Part of the idea behind gamification is to understand which mechanics keep gamers motivated to come back to play and apply those constructs to non-game environments with the goal of encouraging similar engagement. Since these have been shown to work (Lepper et al., 1999; Charles et al., 2011; Rebitzer and Taylor, 2011), some typical game mechanics were incorporated into the classroom as listed in Table 1.

Table 1: Theoretical Motivators / Classroom Realization.

	Mechanics	Realization
External Motivators Platform	Aesthetics	Gamification platform
	Progress Bar Overview	Poster on wall Gamification platform
	Feedback	Moodle online quiz
	Leaderboards	Email (anonymous)
	Points, Levels Heroes	Gamification platform
Internal Motivators Classroom	Autonomy	Lecture on demand Various paths though content Personal timeline Personal learning materials and interaction
	Mastery	Quiz until mastery Bloom’s Taxonomy
	Purpose	2 Semesters Project based
	Basic Needs	Teaching to the test

2.2 Content

Content is structured to support intrinsic motivation of autonomy as defined above for the purpose of this work. A choice of independent pathways organized into levels through the material is provided. Each of three paths consists of three topics of mastery divided into Bloom’s cognitive levels as described below (see also Table 1).

2.2.1 Topic Organization into Levels

Topics covered in this Software Engineering course is structured into three pillars of three topics each: Software writing (Design Patterns, Metrics, Testing), Communication (Documentation, Estimation, Reverse Engineering) and Project Management (Processes, Configuration Management, Lifecycle Management) and culminates in project based experience. The current version of the topic separates the theoretical parts into the first Quarter and the project part into the second Quarter, with students spending the intermittent Quarter in their respective work places. This separation is designed to give students enough time to learn all aspects of Software Engineering before applying the collective know-how in a project. Additionally, tuned into the subtopics, they are able to inspect how these topics are treated in their workplace during their practical phase, thereby integrating industry know-how into the classroom.

2.2.2 Towards High-level Thinking with Bloom’s Taxonomy

Bloom's taxonomy classifies educational goals into a hierarchical system in the cognitive domain and builds towards higher level thinking skills and has been used effectively in Computer Science in the past (Krathwohl, 2002; Thompson et al., 2008). An example is depicted in Figure 1 for the topic of Software Testing. At the knowledge level, students receive a theoretical lecture on demand. Here, terminology, facts, principles and theories are presented. For the example of testing the lecture explains what the different types of software tests are, when they are performed and what they cover.

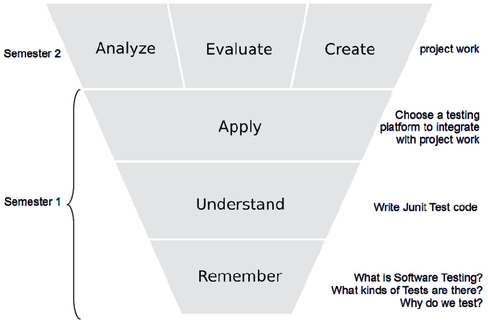

Figure 1: Bloom's Taxonomy (Bloom ’56) as applied to one of the learning areas in Software Engineering.

Understanding the facts is encouraged by asking students to then implement several unit tests for a given suggested code or a code of their own choice. They are then asked to choose a testing framework for later use in their projects to prepare for the next semester. For example, how can tests be automated and tied in with the lifecycle management. Analysis, Evaluation and Creation of further tests is then left to the actual project based experience in the next Quarter/Semester in a larger scale testing environment.

2.3 Blended Learning

Learning platform(s) are integrated into the classroom in order to create a blended learning environment to match motivators (Bekele, 2010; Graham, 2006; Mohammad and Job, 2012) with the known shortcoming of not living up to professional graphic interfaces that people are used to these days (Schober and Keller, 2012). Table 1 lists the connections that were implemented in this case to align motivators with elements of blended learning environment.

2.3.1 E-Platforms

Lecture slides and learning objectives for each of the nine topics to be studied where provided on Moodle and supplemented with links to external information and tools. Online quizzes provided a 24x7 platform for submitting work to be checked manually by the lecturer to provide more or less immediate and personal feedback. In addition, a separate gamification platform apart from Moodle supplied explicit task lists, levels, points, a progress bar and an overview over class progress that was also available in paper form on the wall.

2.3.2 Human Interaction

With 5 hours of in-class time per week and mandatory attendance, this time is used for teamwork among students and choosing frontal lectures on any of the nine topics on demand as the student progresses through the topics (levels). Theoretically, the student has the opportunity to pick up to 9 lectures in any order over the course of 11 weeks duration of the quarter and work through related problem sets and quizzes with feedback from instructor with no restriction on collaboration. Only six topics were required for the final exam that covers only the "remember" level of Bloom's taxonomy but would be facilitated by understanding the topics more thoroughly after completing all three of Bloom's cognitive levels per topic. The next section will describe the experience from the teacher point of view.

3 PERCEPTION OF THE LECTURER

The expectation of the lecturer was a general relief on the part of the students to be able to work autonomously with increased time in an environment of knowledgeable students, where a lecture could be held on demand in small groups that allowed more questions and interactions and control over lecture times. No longer would a student have to pay attention on demand by the teacher, but vice versa.

In reality, students took a long time to warm up to the new system as they did not ask for lectures during the first weeks but tried to just read the slides. Students were also unable to schedule their own pace through the material despite the fact that the lecturer gave example schedules for various different pathways through the three pillars. Students usually did not resubmit quizzes that did not receive optimal points by instructor through Moodle.

Students sitting in a frontal lecture often seem to subside in an impassionate "coma" not being able to take breaks or rewind. In the new mode, I see students sitting in small groups in front of computers discussing how to solve the given problems. They take breaks when they need them, move their post-it notes to the next level once they have accomplished a level. They collaborate in various sized groups or work on their own with a headset listening to music. They are aware of who is working in a similar area and after some weeks were able to prepare and request frontal lectures in groups of 2-10. These lectures were always given within the three-hour class-time following their demand. During peak time in the middle of the quarter, up to three lectures on different topics where given in one session to various subgroups. These students came prepared, asked questions and gave feedback as to the quality of the lecture, which could then be immediately improved for the next groups.

As a result, motivation for the lecturer has increased. While it would be hard to prove quantitatively, it is apparent in comparison to other classrooms that the questions were asked without intimidation and with more background knowledge and depth. Because of this positive perception on the part of the lecturer, the student perception explained in Section 4 came as a surprise.

4 QUANTITATIVE ANALYSIS OF STUDENT SURVEY

An exploratory survey was conducted to find out what students expect from a good class and how they are motivated in order to receive feedback on the class set up and how well it matches their motivators. The survey was not mandatory and 59 students chose to anticipate in anonymous manner during weeks 8 and 9 out of a total of 11. These responses form the basis of the reported analysis. To get a rough idea about how well the course was received, students were asked to give it a grade. In Figure 2 below, which plots grading of a student for an average frontal lecture minus the grading of Software Engineering on a scale of 1 (best) to 6 (worst), it can be seen that grading for Software Engineering (open format) is about equal (with mean around zero) with a tendency toward preferring the frontal, known style (distribution tends to left side). After years of school training to learn to the test it may not be surprising to see that students will have problems with the new learning environment. Still it was surprising since above mentioned research had suggested otherwise.

The following sections will evaluate the student survey that was designed to elucidate their expectations of a good lecture and their motivators with respect to the research based categories of autonomy, purpose and mastery. The hypothesis was naively that the proposed learning environment was much more closely aligned to their motivators.

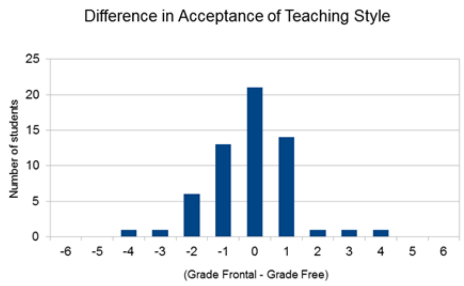

Figure 2: Grade of Frontal - Free Lecture Style.

4.1 Student Profiles

It is of interest to study how students' profiles differ according to how they like each format (frontal vs. Software Engineering). Based on the grades the students gave, they were grouped into "Dislike", giving a bad grade (1 <= grade < 3) and "Like", giving a good grade (3 < grade <= 6) for each format. The resulting number of students in each category is shown in Table 2:

Table 2: Subset of Students with Strong Dis/Likes.

# of students	Like (grade < 3)	Dislike (grade > 3)
Software Engineering	21	19
Average Frontal Lecture	20	9

4.1.1 Perception of Format

Two hypotheses were that students grow to like the format after getting used to it and that prior knowledge would automatically lead to a higher acceptance of the course format.

As expected, students who like the new format noted an improvement of the format over time. However, students who dislike the format alarmingly worsened their opinion over time indicating a lack of necessary scaffolding.

As frontal lecture treats every student the same, whereas the free choices afforded students to move past topics according to their own needs, students with prior knowledge are expected to prefer open style lecture of Software Engineering to average frontal lecture. Strangely, Figure 3 shows that opinion on the course format is not a function of prior knowledge, which as will be seen later, does not suggest a lack of challenging problems.

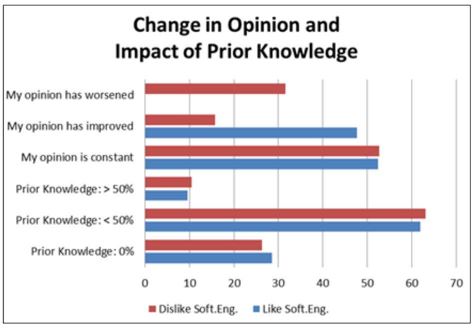

Figure 3: Impact of previous know-how on acceptance of course format and change in opinion.

4.1.2 Students' Expectation of Lecturer

In order to understand the acceptance of the new format, the survey also gathered information on desired characteristics of a lecturer that are perceived as desirable. Due to his point of view and experience, the list given in Figure 4 was designed by a student from the graduating class.

The hypothesis was that a teacher should know how to teach and have expertise both in theory and work experience. Yet, students overwhelmingly answered that it is important to see problems, solutions and obtain a script (in Germany this is a transcript of a lecture, which is more concise than a textbook). This seems to point towards students that are training to the test.

Looking at students' responses in terms of their format preferences, we would expect students who like the Software Engineering open format to put less emphasis on slides and script. This hypothesis is

shown to be mostly supported by the data. However, mostly there is no difference between the groups.
The data revealed additionally, that students who dislike frontal lecture were looking for more for theoretical know-how and practical experience in a lecturer (which they probably did not get since they didn't like the lecture) and to get the necessary content find both slides and textbooks more important than other subgroups (see Figure 5).

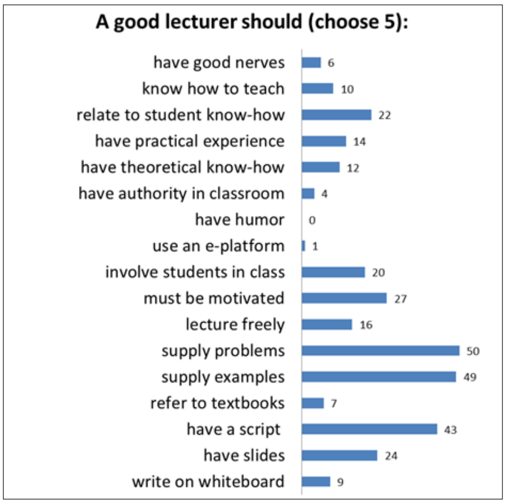

Figure 4: Number of students who choose specific lecture characteristic.

A new hypothesis based on this result is that these students would prefer the free format of Software Engineering. Figure 6 shows that grades given by students show a tendency of anti-correlation between frontal and free style of teaching.

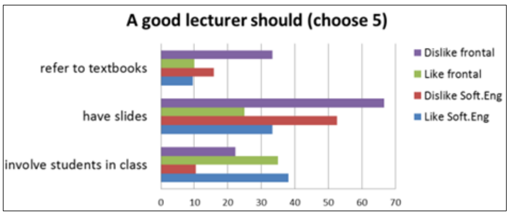

Figure 5: Students' opinion based on subgroups. Numbers are given in % for comparison.

In summary it can probably be said that if the lecturer is good, interaction is important, otherwise the lecturer becomes irrelevant and students seek their information in slides, script and lastly books if necessary – no matter the format of the course.

4.1.3 Students Motivators

Since one of the key design elements of the new format builds on motivating students according to research-based ideas on what motivates humans in general, it is of interest to poll students on their motivators in alignment with the elements in Table 1 above. Under the elements of purpose, mastery, autonomy, and extrinsic (grade) / intrinsic (content) motivation, the questionnaire seeks to explore which elements are motivating for students.

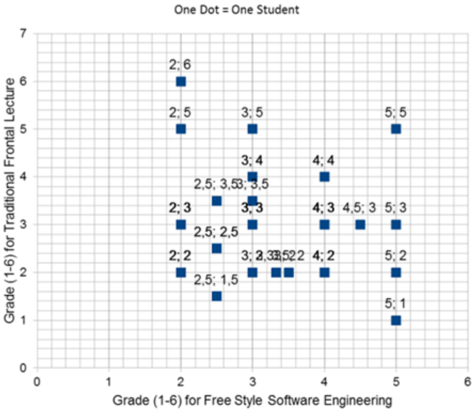

Figure 6: Tendency of anti-correlated grades for frontal vs. free style Software Engineering.

Added categories include challenges and urgency from game mechanics. The original hypothesis that we wanted to explore was whether students can be grouped by motivators that can then be catered to in different teaching styles and with different mechanics.

Figure 7: Number of students who voted motivator as important (choosing up to four motivators).

Instead, there was an overwhelming response across all students regarding purpose and path as the main motivators (Fig.7). After asking students, this is to be interpreted within the framework of taking an exam and obtaining a high grade. The clear path refers to receiving material from the teacher that prepares for the exam with the purpose of knowing this material to obtain a good/passing grade. The key is to fulfill the basic needs of staying in the program. Looking at the subgroups, however, there are some clear differences between the two groups with respect to some of the secondary motivating factors. Figure 8 depicts some of the more pronounced differences. Students who enjoy either format (green, blue) like receiving feedback about their learning status. Time to experiment with new material and content tends to be more important for those who like the open style of the Software Engineering course than for any of the other subgroups. This goes along with our expectations but is clearly and strongly overshadowed by the motivators fulfilling the basic needs.

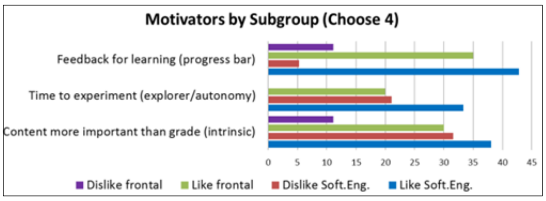

Figure 8: Student Motivators by rating on new format. Numbers are given in % of subgroup.

Because the new format required self-discipline in scheduling the material and a fair amount of team work, another set of questions is designed to find out whether students' dislike of teamwork is related to the dislike of the new format. 80% of those students who enjoy the new format like working in small groups. Only 30% of students who dislike the new format only enjoy working in teams.

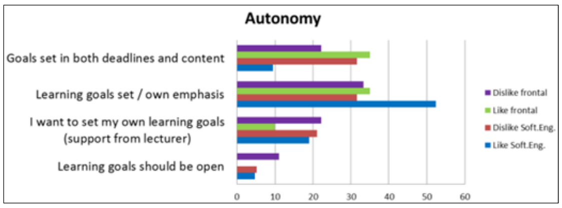

Figure 9: Setting own goals by rating on new format. Results are given in % for subgroups.

The original hypothesis was that most students would welcome the motivation of being able to work autonomously as a relaxing contrast to most of the other "clocked" courses. Figure 9 depicts students' desire regarding autonomy with respect to scheduling of content according to subgroups and supports our hypothesis only for the subgroup of students who like the free style.

4.2 Matching Motivational Factors

Finally, it is important to see how the motivational factors that are important to students match up with their perceived experience of the different lecture styles. In order to understand this, the same questions have been asked about the average frontal lecture in comparison with this particular Software Engineering format in order to see how the results compare.

Questions relate to the three motivators purpose, mastery and autonomy as well as some questions that relate to whether or not the basic needs, such as performing well on the exam, are met. Figure 10 contrasts the replies corresponding to the average frontal lecture when compared to Software Engineering using the new format with numbers given in % of 59 of those students who answered with yes out of yes/no answers possible. While the new format loses on fulfilling the basic need of a student for efficiency and feeling prepared for the final exam, the new format wins on aspects of lecturer adapting to individual needs, students wanting to understand the material and granting autonomy. Still, with either format there is not enough time to master the material properly.

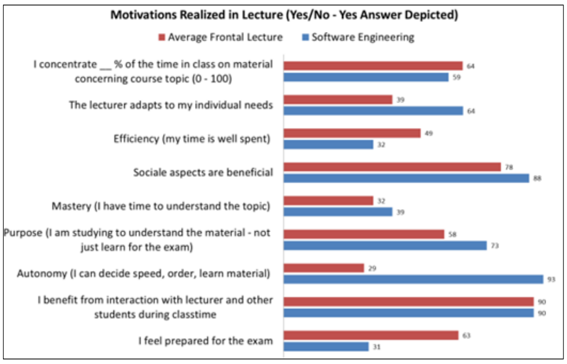

Figure 10: How well are motivators fulfilled in frontal lecture and new format classroom?

Figure 11 shows how opinions differ for each of the four subgroups to gain a more detailed understanding of the results. More students who like the new format feel that the lecturer adapts to their individual needs. Students who dislike frontal lectures or like the new format tend to be more interested in studying to understand the material (mastery) rather than learning just for the exam. Students with strong feelings either way about the new format agree that the new format grants more autonomy with respect to speed and order of the material. On the other hand, students who have strong feelings about frontal lectures strangely do not perceive autonomy granted by new format. It is possible that autonomy may be perceived negatively as being forced to work during class time.

Looking back at the analysis that shows that the primary motivator was to fulfill the basic needs of staying in the program with good grades, it is especially disturbing that students who do not like the new format are especially concerned about the efficiency of in-class time when compared to frontal lectures.

Despite individual feedback on their performance using online quizzes throughout the semester, most students regardless of subgroup, tend to feel less prepared for the exam when compared to a frontal lecture. After conferring with students on this finding, it seems that the reason for this are the open problems, no clear script to follow and more than one correct answer for the higher level problems, which makes it very difficult to know when preparation for an exam has ended. This mismatch of basic needs and fulfillment is problematic.

5 QUALITATIVE ANALYSIS OF STUDENT FEEDBACK

General student qualitative feedback, especially for those that struggled with the new format reflected three major areas: 1. the importance of knowing how to obtain a good grade, 2. the difficulty of on-boarding in this new learning style, 3. the lack of supporting material even after buy-in to the new format.

5.1 Open Questions vs. Clear Answers

The importance of the exam and the grade and as a result the desire for clear "structure" - meaning that the lectures should be very exact in preparing the student for the exam by clearly covering necessary material, sample questions and corresponding answers that are known to be correct is clearly the equivalent of the basic need that should be fulfilled given the students' "ecosystem" at the University. This student goal is diagonally opposed to the inability to memorize the correct answer to a question like:

"List and weigh important criteria when selecting a supporting tool for Lifecycle Management. Then compare two tools of your choice and argue your final choice based on your chosen criteria and assumptions." While this may be a real-life question as it would be posed in the workplace, it is not a "good" exam question (like "What does UML stand for?") as it does not have a single correct response that could potentially be memorized. A good answer would reflect how much time a student has spent looking at what Lifecycle Management is (information given in a lecture), what kinds of processes it can support (lecture) finally what types of tools and capabilities are available on the market and which features distinguish these (research on the web with provided links to start). The student has to be able to analytically formulate criteria based on assumptions that are important to a project and with those in mind compare a number of tools. This requires analytical thinking and transfer of know-how to unknown situations, an important skill with constantly changing tools in information technology. There is no correct answer and assumptions have to be stated as part of the answer to the question. Yet, results from this work show a clear need for facilitating the move towards answering these kinds of questions.

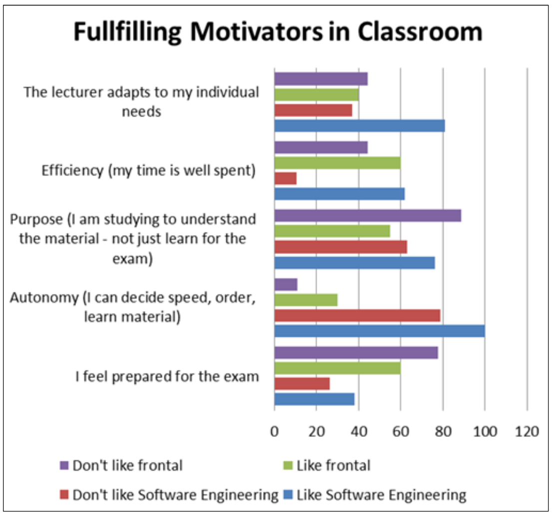

Figure 11: Contrasting how motivators are fulfilled in Software Engineering for all different subgroups (in %.).

5.2 On-boarding

Key take-home message from feedback of all students is that the on-boarding process, the steps from frontal lecture to free learning has to be gradual and guided. Students had problems with

- scheduling their own work
- asking for lectures on demand
- using the platform to their advantage (taking quizzes regularly, improving answers upon feedback, contacting expert students for help)

- leveraging in-class time (collaboration, lectures)
- understanding that a question has more than one correct answer

Feedback clarified the need for providing more scaffolding at the beginning of the class and removing these at rates depending on the individual student. One of the questions on the questionnaire asked students how they could have taken better advantage of the new format of learning. It is remarkable to note that only around five students were able to reflect on their own ability to cope with the new format. The importance of acknowledging such difficulties and the need to "[…] intentionally articulate[…] and foster[…] self-reflection and awareness of processes important to learning such as self-efficacy" (Shea, 2010, p. 1727) has been documented in the literature.

5.3 Learning Material

Due to the misunderstandings of how students relate to the materials that are given in the classroom, all material has to be reviewed to support more self-study and rely less on interaction between lecturer and student. It has to be clarified that slides are not meant to be stand-alone material. They cannot replace reading a textbook, which is how students expect to use them. Scripts in form of related books need to be made more explicit. Problems have to be more structured and even more explicitly marked as closed form vs. open form answers based on inference or analytic thinking. There were four different platforms used for the first couple of weeks before settling on two. A single platform, even if suboptimal, is essential.

6 CONCLUSIONS AND FUTURE WORK

A software engineering course was redesigned to sort topics into paths and cognitive levels, game mechanics were added and tools used to support some of those mechanics to include motivators into the classroom that are well known in the literatures. Results showed that the primary needs for students in a restricted grade-based environment were not met in the given setup. Change management has to be incorporated into the course to improve acceptance beyond the type of student who is ready for this new format.

The following changes are proposed based on the findings: In order to survive, the design of this course has to take into account the surrounding ecology that is heavily grade-based and time-constrained. It is necessary to meet the basic needs of the students to make the path to good grades clear (Maslow, '43). Yet, making this path too easy to obtain more time to spend on deepening understanding may cause other parts of the ecosystem (other classes) to infringe on time that is superfluous according to students' goals. Portfolios that count toward points on the exam may be part of the solution.

Students feel that they have no overview over all necessary and important areas of study. While they will acquire knowledge in all areas during the course of the third quarter, this was reportedly uncomfortable. Giving an overview lecture of the nine areas of study is very important. While students were worried about missing something, only two attended all nine lectures on their own accord.

The increasing difficulty due to increasing openness of problem statements within Bloom's taxonomy has to be made explicit through improved material and increased scaffolding showing example answers and arguments for all levels. In combination with the known need by employers for this capability, there is a clear need to manage this change in most students' manner of working and acquiring higher-order thinking skills.

The study showed clearly that the semantics behind motivators such as autonomy, purpose and mastery are defined differently for students. Mastery relates to memorizing material for an exam in such a way as to receive a good grade. Autonomy means that a student is able to not participate during class time and choose their own time for learning. Purpose is to receive the necessary grades to obtain a Bachelor degree to obtain a good job. These terms have been defined throughout prescriptive school, University and life in society that expects diplomas. Even phases on the job within their time of study have not had an effect on these definitions by the time students reach their second year of study. Further study is necessary to find out whether this perception will change before the Bachelor is obtained. In order to manage this change of perception it may be necessary to include employers' in this dialogue by inviting them to class.

Future work includes reporting on the proposed changes and further feedback to be collected from the present group to find out long-term effects of the learning experience after the end of second semester.

ACKNOWLEDGEMENTS

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Learning Strategy and Students' Perception of Different Learning Options in a Blended Learning Environment

A Case Study of a First Year Engineering Course

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Keywords: Blended Learning, Learning Styles, Active Learning, Students' Satisfaction, Engineering Dynamics.

Abstract: This case study presents a teaching strategy for an engineering dynamics course using a range of different learning options supporting different learning styles. The teaching strategy was implemented in a blended learning environment by combining traditional lectures with online resources. A set of questionnaire was given to evaluate the students' perception of the different learning options. The study shows that the students found online pencasts very useful as a means to increase the outcome of studying a traditional textbook. In addition, the implementation of an electronic audience response system to enhance active learning by peer instruction in combination with traditional lecturing was highly appreciated by the students. Finally, the study indicates that according to the students the proposed teaching strategy leads to increased motivation and engagement in their study.

1 INTRODUCTION

Helping young students to become skilled and innovative engineers is not an easy task. One of many issues is how to transfer knowledge earned in a theoretical course into useful competencies when dealing with real engineering problems. The Faculty of Engineering at the University of Southern Denmark has tried to address this problem by assigning 1/3 of the student's work load each semester to a specific semester project comparable to a real-life engineering problem. The idea is that the students learn how to use the theory discussed at the more traditional courses, thereby finding the theoretical courses relevant and in fact crucial for their education. In spite of all good intentions with these semester projects, it does not always work that ideal! For instance, when talking engineering dynamics, it is striking that while students might be good at solving text book exercises, this does not imply that they are able to use their knowledge in more realistic engineering problems that they encounter in a semester project (Schmidt, 2012). As an attempt to overcome this challenge the teaching strategy in a theoretical course in fundamental engineering dynamics was changed by setting up a blended learning environment.

With the advancement of technology the use of blended (or hybrid) learning at university level has developed a lot over the last decade. This teaching strategy can be defined as 'a mix of several didactic methods and delivery formats' (Kerres and de Witt, 2003). Moebs and Weibelzahl (2006) advocate for blended learning being the integrated learning activities such as a mixture of online and face-to-face learning. In this context we will adopt to a type of blended learning where different traditional teaching styles are combined with different kinds of e-learning - a definition that seems to be more often used in the literature (Oliver and Trigwel, 2005).

The increased use of blended learning is a consequence of not only the progress in technology but also of the economical and political conditions for educational institutions and of the globalization in general. Many universities face a reality where they have to teach more students with fewer teachers (Peercy and Cramer, 2011). Blended programmes have been suggested as a way to increase cost-effectiveness in education, i.e. the learning outcome is maintained or even increased despite a reduction in teaching costs (Graham et al., 2005). The increased access and flexibility offered in a blended learning environment enhances distance learning, too, and thereby gives a possibility to reach a larger student volume with a positive influence on cost-effectiveness as a result.

On the other hand there are a range of reasons of more pedagogical nature, why blended learning by some have been proposed even as the ideal teaching concept for the future (Cortizo et al., 2010 and Granic et al., 2009). This is due to the fact that as student population growths the teachers find themselves with an impossible task: to choose the optimum teaching style for the students. Even if all the relevant teaching styles are known, it is not possible to implement all these teaching styles simultaneously at class to meet the students' needs (Felder and Brent, 2005). Students who have different needs, different background levels of knowledge and different learning styles are equally not satisfied with traditional teaching and learning environments (Limniou and Smith, 2010). Implementation of blended learning is seen as a promising strategy to address this problem, since it allows integration of traditional learning with web-based or computer-based learning tools and combinations of a number of pedagogical approaches (Dzakiria et al., 2006).

As pointed out by Peercy and Cramer (2011), successful blended learning cannot be a mish-mash of traditional lecturing with some online content but needs to involve a thoughtful redesign course pedagogy implying meaningful new interactions with students. This paper reports how a blended learning structure was established in a second semester engineering dynamics course. Special emphasis was put on facilitating several learning styles and on increasing the learning output by stimulating active learning. At the end of the semester a survey was carried out in order to measure the students' perception of the efficiency of the different learning options as a first indication of the strength of the proposed learning environment. In addition it was possible to track the number of students viewing the online materials and in this way getting data on the use of these materials.

2 RELATED WORK

When designing a course structure to benefit from blended learning it is important to strive for the blend to involve the strengths of each type of learning environment and none of the weaknesses. Osguthorpe and Graham (2003) have identified six general goals to aim for in this context: (1) pedagogical richness, (2) access to knowledge, (3) social interactions, (4) personal agency (learner control), (5) cost effectiveness, (6) ease of revision. It is crucial to consider how or to what extend these goals can be achieved when blended learning is implemented into a course design.

In engineering educational research quite some work on how to use a blended learning strategy has been published, but not particularly in engineering dynamics. Boyle (2005) shows how such a strategy used in an introductory programming course can address a common problem dealing with the abstract nature of certain programming concepts. Here a development of multimedia learning objects enabled the students to engage visually with these concepts and hence overcome the problem of abstraction. Another study on a blended learning approach in a computer programming course for first year engineering students indicate that online tools can be very beneficial for the students, and it improves the student satisfaction with the course (El-Zein et al., 2009). Groen and Carmody (2005) found that in teaching first year engineering mathematics the blend more closely mirrors the professional practice and is more likely to encourage a deep approach to learning. The majority of the students responded favourably to the blend. Similar results on positive student feedback and especially regarding improved student motivation in engineering mathematics has been reported by Wan Ahmad et al. (2008). A particular interesting approach to design a mathematics course within a blended learning framework has been suggested by Markvorsen and Schmidt (2012). They consider the technology enhanced learning of first year engineering mathematics and especially the application of different e-learning objects and principles. Because of a yearly intake of 750 students at this course, it has been possible to allocate a significant amount of resources into producing introductory videos, interactive web-based tutorials, online textbook materials, pencasts, and podcasts of the lectures etc. Even though the effect of their non-linear multimedia technology and e-learning principles is not yet fully analyzed, they can report that it strengthens and enhances the students' desire and ability to prepare for teaching, and they have received positive response from the students regarding the facilitation of different learning styles.

In engineering education it has been explained that e-learning in general is most effective when used as a supplement to more traditional strategies rather than a replacement for them (Lux and Davidson, 2003). In fact, traditionally the science- and mathematics-based engineering courses are the hardest to teach online because of the need for laboratories and equation manipulation (Bourne et al., 2005). Newer research shows that to improve the success of blended learning the teacher should adopt strategies that promote not only teacher-student interactions, but also enhances class attendance, student-student interactions and motivation (Martínez-Caro and Campuzano-Bolarín, 2011). These findings agree with a study on students' perspectives on learning in a blended environment (Limniou and Smith, 2010), where students stated that their learning output could be improved by using a more interactive teaching approach with the use of collaboration tools and receiving individual feedback. A method to facilitate a more interactive learning frame is to include peer-instruction in the classroom. This teaching style has been found to be very efficient also in a mathematics-based topic as dynamics and in physics in general (Mazur, 1997). Peer-instruction can be enhanced by introducing an electronic audience response system like 'clickers' in the teaching (Fies and Marshall, 2006; Nagy-Shadman and Desrochers, 2008). Some results on students' satisfaction with clicker-induced learning in engineering dynamics has been reported by Fang (2009), who found that students appreciate this teaching approach and the exam performance seemed to be enhanced, too. Another study on peer instruction supported by clickers in an engineering dynamics course revealed that it led to an increased learning output, especially regarding the students' conceptual understanding of the subject. Furthermore, the data showed the students to be very satisfied with this teaching style and they gave high rankings on several parameters, which are important to the learning process (Schmidt, 2011).

Hence, there is a wide range of learning options that can be facilitated in a blended learning environment. However, it is important to keep in mind that the course structure should be very transparent to the students in order to help the students managing their time in such environments and maintaining their self-motivation (Marino, 2000). Since the development of a range of learning options is a resource demanding process, this will usually be a limiting factor, and especially for smaller classes. This was very much the case for the course considered in this paper. The blended learning environment developed here is outlined in the next section.

3 BLENDED STRUCTURE IN AN ENGINEERING DYNAMICS COURSE

3.1 Course Setup

The course studied was a second semester engineering dynamics course. Topics were dynamics of rigid bodies and it was a follow-up on an introductory course on particle dynamics at the first semester.

A total number of 56 students from three different engineering programmes were enrolled at the course. By the study administration the students were divided into two classes because of the use of two teaching languages (Table 1). Both classes were taught by use of the same blended learning approach and by the same teacher, hence in this work all 56 students are treated as belonging to just one sample. Lectures of 90 minutes were given once a week to each class. The students were evaluated for their final grades at an oral examination.

Table 1: Demographic data.

Language	Engineering programmes	Number of students
English class	Mechatronics Innovation & Business Interaction Design	42
Danish class	Mechatronics	14

3.2 Learning Options and Resources

The following study materials were offered to the students. All materials were available online at the course web-page, except for the textbook.

Pencasts. A pencast is a computerfile where a hand-written note is recorded along with the instructor's vocal explanations. This file can be watched by the student in real-time. One advantage is that the student can repeat difficult steps over and over and hear the instructor's explanations for exactly this part as many times as wanted. To each lecture a pencast of 6-9 minutes were developed telling about the main concepts of the week and how they were related to each other and to previous discussed concepts.

Lecture notes. These were hand-written pdf-files consisting of theory and examples for the week's topic. The purpose of the lecture notes was a two-fold: To prepare the student before reading the textbook and save time at the lectures because students did not have to takes notes all the time.

Textbook. The textbook used was a standard engineering dynamics textbook by Meriam and Craige (2008).

Voting Tests. These tests consisted of six to nine multiple choice questions for each lecture. The questions were made to challenge the students' general understanding of the topic and their conceptual understanding in particular. At the lectures the students voted (by use of clickers) on the answers they found to be correct and the results were used to stimulate peer-discussions. Mainly, the voting tests were uploaded in order to give the students the possibility of working with the test questions not only at class but after class, too.

Hints and Answers. To each lecture a number of exercises were recommended for individual study or group work. To encourage students to work on these exercises a file with hints and answers were uploaded to the web-page each week.

Discussion Boards. The students had to hand-in three individual assignments during the course and to each of the assignments a discussion board was created in order to facilitate student-to-student interactions regarding this work.

Other Materials. Occasionally, the students were given links to existing online materials, youtube clips, etc. and online materials suggested by the students were distributed on the web-page, too.

3.3 Suggested Learning Strategy

At the beginning of the course the students were carefully presented for the range of learning options. They were recommended to start up applying the learning strategy sketched in Figure 1 as this was seen as a strategy that probably would suit a majority of students.

As shown in Figure 1 the students were suggested to start a new topic by watching the pencast. This should prepare them to achieve a better outcome when studying the textbook before attending class. The lecture notes were supposed to help the students with this task, too.

Hence, when students met in the classroom, they had already studied the subject and gone through some sample problems in the textbook. For this reason, the teacher gave only a short presentation to cover the most important parts of the topic (typically 10-15 minutes).

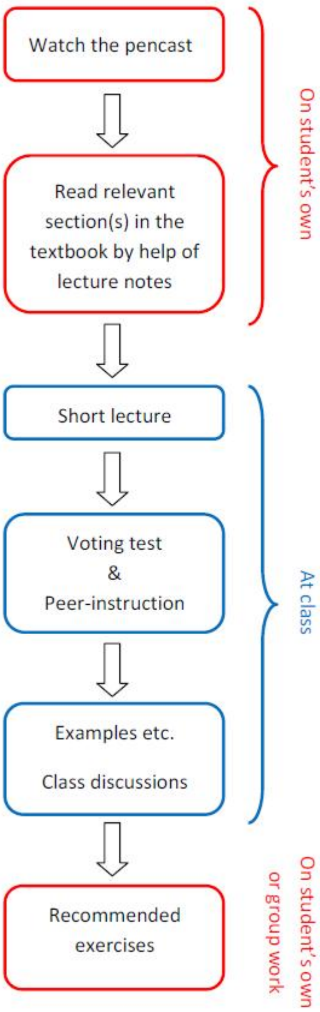

Figure 1: Suggested blended strategy.

Then the voting test was carried out. After presenting a question on the screen, the students were asked to answer the question on their own and give in their answer anonymously through a clicker handed out to each student at the beginning of the lecture. Automatically, the distribution of given answers were shown on the screen to motivate the students for the following peer-discussion. After some minutes of discussions, the students were asked to vote again on the same question. Normally, the second voting showed much better agreement as a result of the peer-discussions. A concise conclusion to the question was stated by either one of the students or the teacher. Usually, this voting-session took up 30-40 minutes. The remaining part of the lecture was held in a more traditional form with focus on working out examples and problems, some of them covered by the lecture notes and some not in order to give possibility to have class-discussions on different problem solving strategies. Occasionally, experiments were carried out at class to demonstrate specific concepts and to relate to real world examples.

The students were urged to work on the recommended exercises after class, either on their own or in study groups. If they were able to solve these exercises the students could see this as an indication of him or her mastering the topic! Only the mandatory assignments were handed-in and to these assignments the students received written feedback on the problem solving skills and presentation of the solution methods.

4 DATA COLLECTION

In order to collect information on how the students used the different learning options and how beneficial they found them, the students filled out an online questionnaire at the end of the course.

For each learning option the students were asked two questions:

(1) How often did you use the [learning option]?

(2) When you used [learning option] how effective (learning outcome per minute you spend) did you find it?

Answers were given on a 5 point likert-scale (1 = ‘Never’/’Not effective at all’ to 5 = ‘Every week’/ ‘Extremely effective’ for question (1) and (2), respectively).

In addition the students were given the opportunity to answer two essay questions: One regarding the student’s explanation on why some learning methods work well for him or her, and another one where the student should explain why some learning methods do not work for him or her.

Data from the questionnaire was gathered electronically and thus answers were given in fully anonymity. A total number of 50 students responded to the questionnaire (corresponding to 89%). The amount of qualitative data from the essay questions was quite significant since 45 students (90% of the respondents) gave input through this channel.

Finally, the number of students viewing the online materials was tracked as a means to monitor to which extend the different materials were used and also to track when they were accessed.

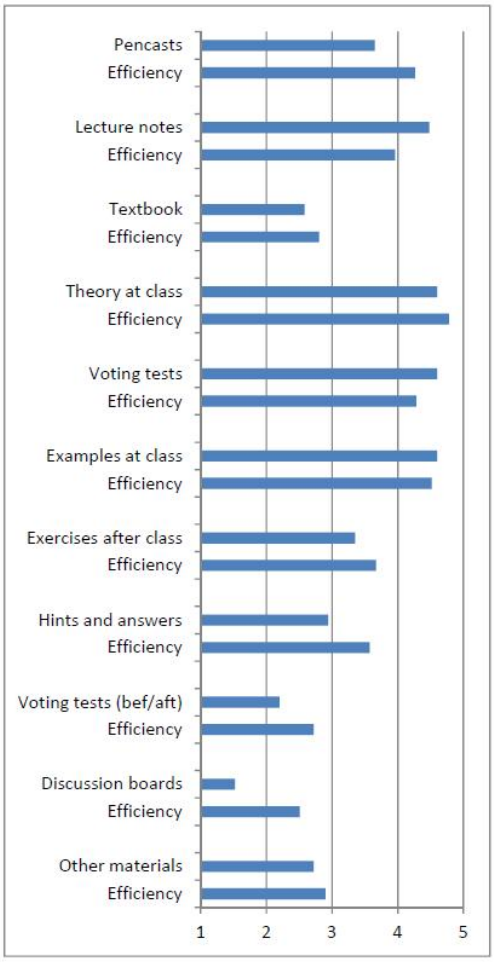

Figure 2: Average scores on use and efficiency.

5 RESULTS

Figure 2 shows the average scores for the different learning options regarding how much the different materials have been used as well as the students’ perception of the efficiency. In general it shows that the students gave the highest ranking to the activities that took place at the lectures (presentation of theory, voting tests/peer-discussions and examples). Reading lecture notes and watching pencasts are considered quite beneficial too, while the use of the voting test questions outside of classes, discussions boards and ‘other materials’ are found to be more rarely used and with poorer efficiency.

Even though not documented here, when comparing the scores on the use of the different materials given by the students and the tracking of the number of views they seem to agree well. Hence, the results on the use shown in Figure 2 are considered quite reliable. Regarding the data on efficiency, being of a more subjective nature, it is unfortunately not possible to make any kind of comparison in order to validate the data.

As an example of the kind of data received from tracking the number of students viewing the online materials, the student views of the pencasts during the semester is shown in Figure 3.

Results from the essay question will be part of the discussion in the following section.

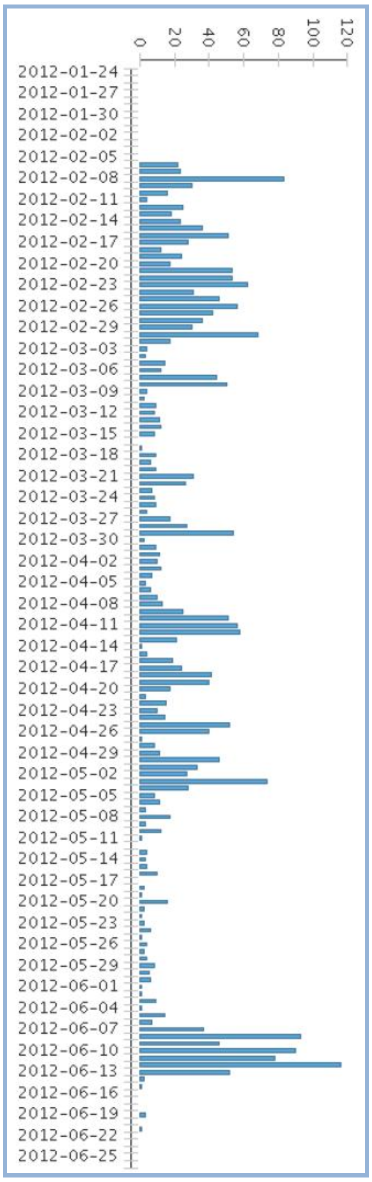

Figure 3: Number of student views of the pencasts during the semester. (Data from the English class).

6 DISCUSSION

6.1 Learning Options before Class

There were three main learning options for the students to work with before class: pencasts, lecture notes and the textbook. Figure 2 gives a very clear indication that while the pencasts and the lecture notes were found to be very useful and efficient, the textbook was found to be one of the learning options with poorest efficiency of them all. Presumably for this reason, the students did not use the book very often. This view on textbook and lecture notes reading was stressed by students' comments on the essay questions:

'Reading in books is just naturally so slow and boring.'

'Personally, I can't learn properly in a book. Some texts are too strange and difficult to read.'

'I read every week the lecture notes - they are really good because they have a nice overview and structure.'

The online lecture notes were found to be very popular among the students. This can be explained, at least partly, by the lecture notes being much easier read compared to the textbook. It is important though, in order to create the optimal learning, that focus is put on the lecture notes being a tool helping the students to benefit from studying the textbook rather than being an alternative to the book. A study by Fitzpatrick *et al.* (2010) indicates that students regard a good set of notes a requirement for a well-taught module, but in general the students are not convinced that this is sufficient. Hence, providing such lecture notes is not seen as an alternative to the textbook in this context. Since most careers in engineering in the future will be based on life-long learning, it is crucial that the students are provided with the skill to benefit from reading a traditional textbook.

Next to lecture notes specially produced video films have been suggested to help to prepare students for studying a textbook (Markvorsen and Schmidt, 2012). Since video production is a rather expensive solution, in this work it was chosen to make use of the pencast technology. Easily and inexpensively created with a digital pen with a build-in audio recorder, pencasts are very useful not at least for a course topic of mathematical nature. The pencasts made for this course was meant as 'appetizers' before reading the textbook but also to achieve direct learning, mainly in the sense of creating an overview of the subject. Figure 2 shows that the students found the pencasts very efficient. Some students' comments on pencasts were:

'The pencasts are very great. They are short and precise - and the best thing: you can repeat every explanation until you've got it all!'

'Pencasts were new to me. It's a cool idea.'

'Pencasts work well for me because of the "listen-to-anywhere-anytime" function. Repeat. Repeat. Repeat!'

In addition, the pencasts might also enhance the students' motivation to read the textbook:

'The pencasts I also think was a good idea to help me kickstart on new theory and made reading the book easier.'

A similar observation has been made for the video introductions by Markvorsen and Schmidt (2012).

An unexpected use of the pencasts can be deduced from figure 3 exploiting the number of students' views on the pencasts during the semester. Right from the beginning of the semester, the pencasts had quite a lot of hits. The decrease in students' views in a part of March was due to cancellation of lectures and a spring break. When the teaching period ended in the beginning of May the students did not access the pencasts very much anymore, but approximately one week before examination (starting June 12) there was a lot of activity again. Hence, even though the pencasts were made in order to be an option to be used before reading the textbook, the students used them quite a lot in preparation for examination.

6.2 Learning Options at Class

All three main elements when the students met at class: the teacher going through theory, voting tests and discussion of examples received high scores in efficiency, well above 4 on the 5-point scale. That a majority of students finds the teacher lecturing beneficial to their learning is in accordance with Fitzpatrick *et al.* (2010), who conclude that students require lectures as well. A lot of effort was put in to lecture on theory and applications in close connection to what the students had seen in the pencasts, in the lecture notes and in the textbook, but always so that the lectures added something new, a new idea, a new point of view etc. to give a further perspective to the subject. According to Fitzpatrick et al. (2010) these are very important factors regarding the students' perception of the efficiency of a lecture. This was supported by students' comments in the present study:

'I think the exercises we did in class and the explanations are very good. I like to work with examples. Then it is easier to remember.'

'Lectures and exercises at class build well upon the lecture notes as they both teach and challenge students. Personally, I appreciate the teaching style because it shows me how to visualize and approach physics problems effectively without tiring me by overloading me with grey theory that has long lost connection to the "real" world. The classes help me to apply theory flexibly with a fair understanding of what is actually going on.'

The voting test sessions at class were considered very efficient by the students, too. Previous work (Schmidt, 2011) has shown that using clickers to stimulate peer instruction can improve the learning outcome and student satisfaction in courses like engineering dynamics. In addition, the present case study indicates that the students themselves assess the efficiency to be quite high. Comments from the students on the voting tests gave credit to this teaching style to enhance satisfaction and motivation as well as to expose students' insight into the core of the learning process:

'Voting tests have satisfied me tremendously as they put the learned theory to test right away and helped me widening the view of physical implication around us.'

'Voting tests inspire students to use each others' knowledge of a given subject, and sometimes their way of seeing a problem differs from the teacher's.'

Facilitating peer instruction is one way to engage the students at class and stimulating active learning. To actively involve the students in the classroom is an important parameter to improve the lecture, according to students' opinions (Fitzpatrick et al., 2010). Findings in the present study indicate that implementing voting tests and peer instruction at class should be considered a recommendable teaching style. In general, the essay answers from students show that the blended environment was quite appreciated by the students:

'Good mix of learning strategies can be the most useful way to learn new things and understand them!'

6.3 Learning Options after Class

Following the suggested learning strategy the main activity for the students after class was to work on the recommended exercises, either on their own or in study groups if preferred. As experienced by the teacher during the semester, the vast majority of students did work on these exercises and this work was seen as important by the students. To the students' disposal, in order to stimulate their work on problem solving, the web-page offered some hints and answers to all these exercises, but the questionnaire reveals that these materials were not accessed very much with an average score of approximately 3 (corresponding to the answer 'now and then'). Some students stated that they learned more from discussing and helping each other than from consulting the 'hints and answers' since they were found to be either too much or too little. Some student comments indicated that it could improve this learning option if it could be given a more interactive form:

'The hints the teacher gave for the exercises could be more like, one hint, second hint, third hint and then if you can't solve it, use the forum...'

A similar result seems to be the case for the 'discussion forum' established for each of three compulsory assignments. The discussion forums were not used very much, and since the benefits in a discussion forum totally depends on the input from the users the forums were not perceived efficient either. Even though the use of discussion forums has been reported very useful in teaching engineering (Brodie, 2009) it was not the case in the course structure described here. Most likely, the reason was that the student volume was too small to create a real need for a discussion forum because most of the students met at different classes every day anyway.

6.4 Limitations

There is a range of limitations in this study appropriate to be mentioned. The small number of students in the sample is reducing the strength of data, even though the response rate was relatively high. The novelty of the pencasts may have produced a Hawthorne effect, which would have had an influence on the students' perception regarding these. On the contrary, this is assumed not to be the case for the voting tests using clickers, since this teaching style was used with the same cohort of students in the previous semester. The students assessing the efficiency of a certain learning option is a very subjective measurement and in some cases it could be misleading. For instance, the students might feel that listening to the lecturer is efficient because they feel safe in that situation, where they are not challenged personally on their learning outcome. Some learning options may be efficient, but may also require a certain level of use. Hence, it is possible that students failed to acknowledge their efficiency, because they abandoned them early. It would be pertinent to include a comparison with the students' learning outcome directly, but it has not been considered within the scope of this work.

7 CONCLUSIONS

The aim of the study reported here was to present a teaching strategy for an engineering dynamics course based on several learning options and resources supporting different learning styles in a blended environment. The students' perception of the use and the efficiency of the different learning options offered were measured in order to optimize the strategy for future courses. In general, students were found to be positive to the blend, and they perceived the chosen elements to be effective regarding their learning outcome. Especially, the students value the variation in teaching style and indicate a positive influence in their motivation and engagement in the course topics.

It was found that pencasts, being an inexpensive and easy-to-adopt technology, can be a very fruitful tool and enhance the outcome and motivation when students are reading a traditional textbook. In addition, the pencasts were found to be useful to the students in their preparation for examination. The online lecture notes were considered efficient by the students too, and the students appreciated the close connection between the notes and the topics discussed at class.

The students found traditional lecturing very efficient, but it is stressed that in this context lecturing took up only a minor part of the time spent at class. Voting tests using clickers as a means to encourage peer discussion were implemented consequently at class, and the students rated the efficiency of such a teaching style high. A vast majority of students valued the alternation between the teacher lecturing, active learning through the voting tests and problem solving through class discussions.

In the present course setup the option of offering hints and answers to exercises and discussion boards on the course web-page were not used very much by the students. The efficiencies of these tools were relatively low, too. To increase these efficiencies it will be considered to create more interactive instruments for the future in order to meet the students' demands.

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Teaching Risk with Virtual Worlds

Experience and Lessons Learnd in Second Life and Other Virtual Worlds

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Keywords: Risk Management, Second Life, Reaction Grid, Immersion, Situated Learning, Virtual Worlds, Project Management.

Abstract: We discuss and demonstrate how Virtual Worlds available at the University of Bedfordshire have been used to teach Project Management using a 'situated learning' approach. In particular we have a closer look on the aspect of teaching risk management and identify how different aspects of risk are addressed in a variety of implementations of Virtual Worlds, namely Second Life, a Virtual World provided by an external provider, not Linden Lab, a Virtual World that is maintained 'in-house' and a Virtual World hosted by the students themselves. We note that the student experience of risk is different in each of these incarnations of a Virtual World which impacts their perception of risk and hence the effects this has concerning the teaching goals.

1 INTRODUCTION

Project management is an inherently inter-disciplinary activity of relevance in many areas ranging from software development to the construction industry. The Project Management Institute (PMI, 2008) defines project management as "the application of knowledge, skill, tools, and techniques to project activities to meet project requirements". In order to teach project management an approach based on team-based, practical, hands-on experience seems most appropriate. Within an educational institution, such as a university, this can be implemented following the 'situated learning' approach developed by Herrington and Oliver (2000) which encompasses parameters such as authentic context, multiple roles as well as perspective and collaborative construction of knowledge.

A prominent knowledge area within the project management profession is risk management. The importance of risk registers and contingency plans need to be part of the practical activities to which students are exposed. In the context of a university activity the risks encountered by the students need to be considered by the educators. Risk embraces an inherent aspect of unpredictability and this should be reflected in the design and implementation of the student activities.

Virtual worlds provide a somewhat controlled environment but still have aspects of uncertainties. Therefore – as we will see in this paper – they provide a useful way to implement risk management within a project management course. This paper discusses how virtual worlds have been used at the University of Bedfordshire to enhance the student experience, in particular in the context of project management and draws conclusions on how different types of virtual worlds impact upon the students' perception of risk.

Indeed, virtual worlds such as Second Life and OpenSim based implementations have been used within teaching of Project Management at the University of Bedfordshire since 2008. The more experimental experience during the early years with Second Life as the platform and Linden Lab as the provider is documented by Conrad, et al. (2009) while a more systematic exposition of the Second Life experience is then detailed within (Conrad, 2011a).

In 2011 a different provider, Reaction Grid, has been used which is based on the OpenSim architecture. While the underpinning technology is similar there are notable differences between these two environments, in particular – as shown by Christopoulos and Conrad (2012) – concerning immersion and context.

The paper is organized as follows. In Section 2 we provide the background on how project management is defined as a combination of nine different knowledge areas and the role of risk management within this framework. Section 3 introduces the 'situated learning' approach and highlights the rationale of using virtual worlds. We then go on in Section 4 to discuss the various ways in which virtual worlds have been used within the University of Bedfordshire so as to facilitate an assignment within project management. Section 5 then focuses on the risks that the students encounter as part of their assignments and Section 6 follows this up by providing a more detailed taxonomy of virtual worlds and how the risk management changes within these worlds.

2 KNOWLEDGE AREAS

The Project Management Institute (PMI) defines Project Management as "the application of knowledge, skills, tools, and techniques to project activities to meet project requirements" (PMI, 2008). In doing so it identifies nine knowledge areas, namely time, cost, scope, quality, risk, human resources, communication, procurement and integration. Most prominently in this list features the so called triple constraint of cost, time and scope. These are clearly interdependent (an apocryphal joke within Project Management is "fast, cheap and good – choose two") in that an early delivery (time) of the product with more features (scope) will imply the necessity of adding more money (cost). In the specific context of a university assignment it is often the case that not all of these knowledge areas can be given equal emphasis: while a pressure to follow time management processes such as using a GANNT chart comes seamlessly from given (external to the project, but implied by the university teaching schedule) deadlines such as submissions dates or weekly status reports the modelling of cost into such an environment is not straightforward as the student activities are usually not constrained by a (real) budget and there are no salary costs. We see that already balancing cost against time is difficult to teach in practice.

Scope and quality control are possibly more straightforward to embed into a university assessment. From anecdotal experience we note that students tend to associate the notion of 'good quality of work' with the idea of 'getting good grades'.

Human resources and communication can be covered to a certain extent by allocating the students into groups plus adding an element of self reflection on team performance.

The knowledge area of 'integration' serves to tie together the various activities to balance the other areas (times, cost, etc.) and can be addressed by exposing the students to an explicit Project Management methodology (such as PRINCE2® at the University of Bedfordshire).

Procurement can be addressed by requiring the project team to interact with an 'external' provider. Here we may distinguish between a true external provider (as can be identified for instance as Linden Labs for our Second Life based assignments) or a "pretend" external provider which is impersonated by the course tutors.

Difficult to incorporate into a university assignment is the knowledge area of risk. Health and safety considerations as well as common sense dictate that students shouldn't be knowingly exposed to 'serious' risk (which is common to real projects) such as damage to health, bankruptcy or other material loss. There is also a perceived or real difference between project risk (that should be professionally managed by the team) and the risk of failing the assessment (which students usually want to avoid at all cost). By definition risk incorporates uncertainty. In a university setting this 'uncertainty' is likely to conflict with a student's desire of clear criteria on how they are expected to perform in their assignment. Therefore an assignment that encompasses risk in a realistic way is not straightforward and need to be crafted carefully so as to provide a good and productive learning experience by embracing certain risks while at the same time addressing the requirements and predictability of a university assignment.

3 SITUATED LEARNING

Conceptually our approach on teaching Project Management follows Wilson (2002) in that "[t]he entire structure of the assessment in this unit was designed as a simulation of an activity that they [the students] were likely to be involved in real life". For this the assignment has been set up to encompass the characteristics of "situated learning" identified by Herrington and Oliver (2000), namely: authentic context, activities and assessment; expert performances; multiple roles and perspectives; collaborative construction of knowledge; reflection and articulation; and finally coaching and scaffolding.

Although very much desirable, assignments following this ideal are often difficult to implement in practice. For instance student experience outside university premises is usually costly and adherence to health and safety standards requires careful organizing. Activities within the university are constrained by available space and facilities.

Virtual worlds offer here a feasible escape route in so far as it widens the students' experience domain while still being contained in a controlled environment. It allows the pursuit of a real, i.e. authentic, project from within the lab environment of an educational institution. It may be indeed a matter of philosophical dispute in what way a project within a virtual world is a 'simulation' or a 'real project'. While the world in which the students act and interact only exists in a computer (and, indeed within the students brains!), therefore being 'virtual', the task requires the students to build real artefacts in albeit a virtual world. The notion of simulated space and real space blur. In fact, it has been argued that there is no real difference between a 'real' and 'virtual' experience (Conrad et al., 2010). This blurring of 'real' and 'virtual' experience however makes virtual worlds an ideal space to teach 'real' issues in a controlled environment.

There is, however, a caveat: virtualization alone doesn't address all characteristics situated learning requires. Multiple roles, collaboration or scaffolding will need to be added as elements to make the assignment successful and relevant. These features have to be embedded as well. In the scope of this paper we focus on the 'authentic context' aspect of situated learning.

4 VIRTUAL WORLDS IN BEDFORDSHIRE

At the University of Bedfordshire virtual worlds have been used in various forms. The journey started with the University acquiring two islands within Second Life in 2007. In Figure 1 the island "University of Bedfordshire" is visible in the foreground with typical university style buildings while the island of "Bedfordia" in the background shows a more 'open' and creative landscape. Indeed, "Bedfordia" was maintained by Teaching & Learning to be used by educators while the island of "University of Bedfordshire" was used by Marketing to promote the virtual activities to the (virtual as well as real, e.g. during open days) public. The availability of these spaces encouraged the author of this paper to utilize the island for his teaching activities. Figure 2 shows the author in discussion with the Head of Learning Technology in 2009 in front of student work. As it happened and implied by the large student numbers of up to 800 per cohort to accommodate eventually both islands were used for teaching activities.

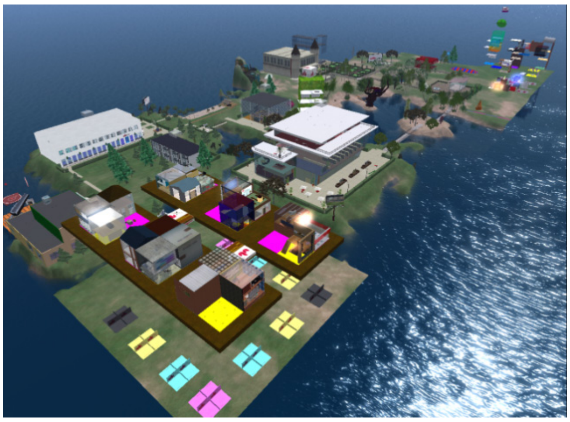

Figure 1: The island "Bedfordia" and "University of Bedfordshire" within Second Life, March 2010.

Figure 2: Two University of Bedfordshire educators in front of student work.

Also visible in Figure 1 and 2 are the student activities that took place on these two islands. In the foreground of Figure 1, in the upper level are the undergraduate student activities of AY 2009/10. On the lower level underneath, areas have been prepared where the postgraduate students start building soon. Other buildings on the island, including a 'library' building prominently in the middle of "University of Bedfordshire" are unrelated to the assignments but provide (virtual) institutional context. In the upper right corner of Figure 1 the remains of the activities in the AY 2008/09 can still be identified. Figure 2 shows a close up of a typical student showcase developed at that time.

One of the activities given to the students – and indeed the least related to the scope of this paper but mentioned here to set the project management activities into context – was the delivery of a five week course about Event Oriented Programming

(Ferg, 2006) There, the Linden Scripting Language (LSL) was introduced as an example of handling events in an embedded system style environment. Lectures consisted of the theoretical concepts plus material adapted from the Second Life LSL wiki. Students wrote simple scripts that interacted with the virtual scenery. A typical example would be an object that changes its appearance when touched or moved. When the relationship between the University of Bedfordshire and Linden Lab as the Second Life provider discontinued the assignment was first moved to an OSGrid island provided by Dreamland Metaverse (Figure 3) in the Academic Year 2010/11. The following year this activity was moved to Reaction Grid.

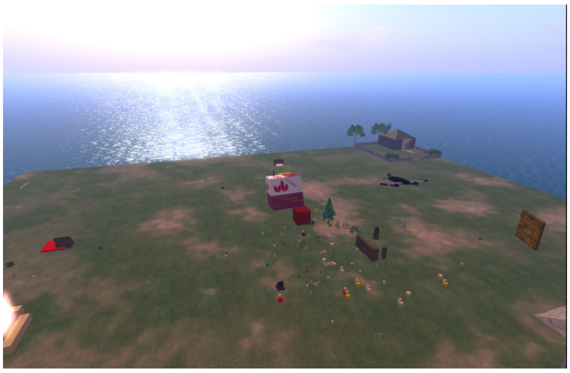

Figure 3: LSL activities on an OSGrid island provided by Dreamland Metaverese.

Project Management is taught both at Postgraduate level and Undergraduate level. The postgraduate course runs every spring for 12 weeks while the undergraduate course is year-long unit across 26 weeks from October to May. Students are required to build a showcase using PRINCE2® as the methodology.

Both courses used the space available within Second Life on the university owned islands until 2010. Then the assignment moved over to Reaction Grid as a provider. The differences and challenges implied by this move (which also included a gap year in the use of Virtual Worlds on the undergraduate course in the Academic Year 2010/11 when no virtual world was readily available: in this teaching year the ‘showcase’ requirement was replaced by a rather unspecific requirement to use web 2.0 technology) are documented by Conrad (2011b): for instance the absence of an in-world economy led to a redesign of the ‘cost management’ and ‘procurement’ aspects of the assignment (and had implications on risk too, see Section 6). Indeed students were encouraged to look at example showcases within Second Life for inspiration while building on the Reaction Grid island; hence utilising in a productive way the similarity between these two worlds.

Figure 4: The island at Reaction Grid, March 2012.

The overall structure of the assignments where similar throughout: students are required to build an in-world presentation (a ‘showcase’) on a topic related to the course of the students.

The more experimental experience from the first year has been published in (Conrad et al., 2009) where the focus was on the suitability of Second Life to be used for an assignment of that kind (which by now can be seen as established, also in view of many other teaching and learning activities within virtual worlds). The main findings identify institutional support as being essential and students mostly do appreciate the use of Second Life in teaching or at least do not object to this. In particular the perceived ‘steep learning curve’ that students have to master in order to get an avatar and to work within Second Life did not seem to constitute an issue for the success of this type of assignment.

The units Social and Professional Project Management (on the undergraduate level) and Professional Project Management (on the postgraduate level) are taught across a number of awards within the field of computing at the University of Bedfordshire. These include awards in Computer Science; Network and Security; Games and Animation; Engineering as well as Business Information Systems. Common to all of these courses is that the students can be expected to be computer literate when they start this course.

The design of the assignment is typically as follows: students are assigned to project teams (the size varies from 3 to 10 or more) and are given a variety of artefacts to be produced, including the showcase within the virtual world. Other artefacts used in the previous years include a PowerPoint presentation, booklets, podcasts or videos. In addition, guidance is given on the use of PRINCE2® as a project management methodology and relevant templates for essential PRINCE2® documentations such as project brief, highlight reports and risk logs are provided. At certain dates the submission of this type of project documentation is required (such as the project brief in the beginning and highlight reports during the course of the assessment). These documents allow the tutors to provide formative feedback. The students are graded according to their individual contribution to the project team.

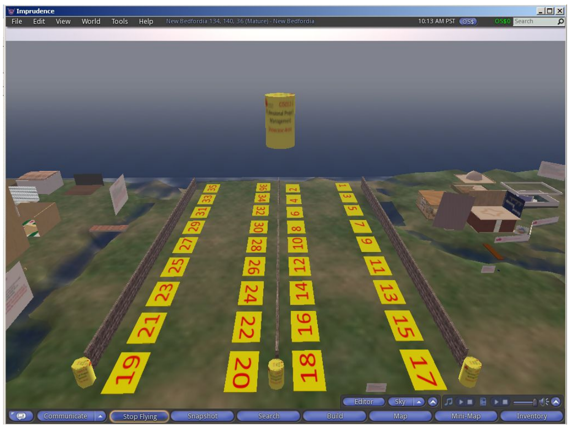

Figure 5: Screenshot presented to the AY 11/12 postgraduate students to illustrate the location where to build.

To illustrate this type of assignment we provide in the following an excerpt of the assignment brief that has been given to the postgraduate students in the Academic Year 2011/2012:

"[…] You are working as a group of 10 individuals who need to come together and work as a team. You will be using the PRINCE2 project management methodology to run a real-life project. As part of an educational advisory team you have been asked to create an educational showcase about an emerging technology. The area that you look at must be directly related to the pathway that you are studying, but may cover any aspect of technology within this area. As part of this project you will have to deliver a number of products.

As a team you must produce the following:

[…]

5) An educational showcase about the technology in a virtual world. Land will be provided at the 'New Bedfordia' island at ReactionGrid. Please note that familiarization with the underlying technology is part of the project work and therefore must be managed as part of the project work; […]

As an individual you must produce the following […]"

Detailed instructions and other resources where then given; for instance the screenshot in Figure 5 (which was made available to the students) helped them to identify the space where they should build their showcase within Reaction Grid.

The following explicit constraint was given as well: "The educational showcase must not exceed an area of 8x8 meters and the maximum height is 5 meters […]. The showcase must be visual appealing." Figure 6 is a screenshot of the same areas as seen in Figure 5 nearly before the completion of the showcases against the end of the assignment.

Further details on the various educational activities, the nature of the student projects including detailed screenshots are available on the author's web site: http://sl.sanfoh.com.

Figure 6: The same area as in Fig. 5 towards the end of the assignment.

5 RISK MANAGEMENT IN VIRTUAL WORLDS

The Project Management Institute (PMI, 2008) defines risk in the context of project management as an uncertainty that can have a negative or positive effect on meeting the project objectives. In particular those risks with negative effects need to be addressed explicitly using appropriate mechanisms. For instance a "risk register" or "risk log" is standard within project management methodologies and used within virtually all professionally managed projects. In order to address risk management as a learning outcome within a university assignment it is necessary to expose the student groups, i.e. the "project teams" to certain risks that need to be managed by the team. From our experience with virtual worlds at the University of Bedfordshire, in the context of the Virtual World environment (Second Life or Reaction Grid), contingency plans should address at least the following situations:

- Availability of the Virtual World on the client side: there are several risks in this context. The Virtual World may not be available for an individual team member, e.g. when working from home with a slow Internet connection or with unsuitable hardware. Contingency plans may then include the redistribution of work to other team members, or the use of a public Internet cafe for certain specific tasks. Clearly the availability of suitable client software within university premises should be established by the educators; nevertheless a temporary problem with these needs to be flagged up as risks for the project as well.

- Availability of the service provider: The worst case scenario is obviously an apocalyptic 'end of the world' which indeed can happen in our simulated environment: the provider discontinues their service. As a matter of fact Reaction Grid did so for this type of (i.e. OpenSim based) virtual world in 2012 moving their business model onwards to other aspects of virtual world provision. It should be noted however – they did so with plenty of notice and it did not affect the course of our assessments. While these risks need to be flagged up and monitored by the project team the resolution of these cannot be expected by the students (i.e. the project team) but need to be escalated to the project board (i.e. the course tutor) for further action.
- Availability of the building area: There are two risks that need to be managed by the project team: the unavailability because the island is overcrowded, or a temporary unavailability due to maintenance by the owner of the island. Second Life had regular periods when regions were taken down for updates etc. In both cases a contingency plan will require the re-scheduling of in-world activities.
- Interference with other groups: Similar to the risk of non-availability of the building area due to overcrowding is the general risk of interference with other groups. Primitives and objects may be misplaced and impact other groups' structures. In such events the situation needs to be managed (typically by contacting the owner of the misplaced object) and the action needs to be properly recorded. Communication here can happen both in-world or in the 'real' world.

Other risks we observed include the accidental delete of (virtual) objects, the unavailability of the avatar due to lost passwords or problems caused by software bugs in Second Life itself (such as data base problems leading to lost items).

The course team needs to ensure proper assessment and grading if such risks materialize. For instance proper project management needs to be acknowledged (with the consequence of good grades) even if some desirable features of the showcase are missing as part of a contingency plan that has been put in place to address problems of unavailability of Second Life. This would be evidenced by documentation of a controlled scope change of the project. In contrast, an unfinished structure that cannot be explained by the project team is not acceptable.

It is however not the role of the course tutors to minimize risks other than those that impact the assessment as a whole. Any action by the course team (for instance removing misplaced objects or to eject / restrict avatars from the island to ease overcrowding) should only be addressed as a response to a formal request of the project manager to the project board.

6 LEVELS OF IMMERSION AND RISK MANAGEMENT

Virtual Worlds provide the opportunity of immersion (Cunningham, 2007) to become part of the virtual world, to lead a 'second life' in its most literal meaning. Indeed this distinguishes virtual worlds from other social and collaborative places such as chat rooms or discussion forums. Questions of identity may raise the debate about the way such a virtual world can or should be separated from the real life experience (Peachy and Childs, 2011). In a university assignment it is a matter of debate what role immersion has to play: eventually student work is assessed in real life with real grades.

Recent studies conducted in the general context of the assignment indicate that immersion plays a role and that there are notable differences between Second Life and Reaction Grid. For instance Kanamgotov et al. (2012) discuss a quantitative evaluation of immersion based on questionnaires distributed to students. The important role of immersion is as well further confirmed in (Christopoulos and Conrad, 2012) where this aspect is investigated in the context of projects outside the University of Bedfordshire.

In the following we discuss how the notion and implementation of risk management is different depending on the direct virtual environment in which the assignment is conducted. Following Conrad (2011b) we distinguish between: the main stream provider (i.e. Second Life), a dedicated provider, an OSgrid based provider, an institutional hosted virtual world and a virtual world hosted by the student him or herself. The first two scenarios are deduced from our direct experience at the University of Bedfordshire when running the assignments while the alternatives where actively considered in preparation for them.

Main stream provider (Second Life): In our experience and following the research cited above Second Life offers the highest degree of immersion compared to the other solutions. The whole concept and marketing strategy appears to be based around the idea of escaping from the 'real world' and the various amenities including shops and party spaces underline this. Project risks may appear from interference of random visitors to the project islands or instabilities of the virtual world itself. Risk management strategies will include interaction with other avatars, possibly even avatars unrelated to the university who visit the university island.

Dedicated provider (e.g. Reaction Grid): While similar to Second Life on the technological level a dedicated provider does not provide the same level of immersion (Kanamgotov et al., 2012) or context (Christopoulos and Conrad, 2013). Risk management might here include interaction with the technical support team of Reaction Grid via their ticketing system. In-world support is unlikely to be encountered due to the sparse population in this world and a low presence of technical support in the form of avatars.

OSgrid provider (e.g. Dreamland Metaverse): The configuration of the OSgrid environment allows the possibility to teleport to various places including those not hosted by the provider of the university island. Promoted as an open source alternative to Second Life many amenities are mirrored within the OSgrid environment. Risk management might here include getting help in user forums and help pages, i.e. by utilizing sources from the Internet but outside the virtual world or to identify available resources within the Hypergrid.

Institutional Virtual World host: The degree of perceived immersion will depend on how the virtual world is set up. It can easily be envisaged (and might even become the norm in the distant future) that university owned 'virtual space' becomes normal within a university similar to 'real' spaces. Facilities such as library, lecture theatres, student union as well as prayer rooms could have a virtual equivalent and being populated with student avatars. Running the assignment in this context would possibly be similar to running the assignment in the context of dedicated spaces within the university. Risk management in this setting would be confined to interaction within university context. While this might be preferable in order to control the assignment it would also take away the interesting aspect of interaction with 'external' stakeholders.

Students host their own Virtual World: Many virtual worlds (one for each student) would co-exist independently from each other. Risk would be very much managed as with other student owned resources. The data on which the world works needs backup and software problems would be escalated to relevant experts or solved DIY style. From all options this seems to be the least desirable as the aforementioned 'situated learning' aspect would be effectively non-existent.

In summary there seems to be a shift from a 'real risk' situation as experienced within Second Life to a 'student risk' situation when moving from Second Life to other provides. The experience of immersion or lack thereof appears to impact the perspective from which risk is perceived. Further research to underpin this observation with solid data would be needed.

7 CONCLUSIONS

Virtual Worlds offer new possibilities in the educational sector and they can certainly help to teach students the essential concepts of Project Management. Indeed areas that are difficult to address in 'conventional' assignments, such as risk are addressed in a more natural way within such a multi user virtual environment.

As demonstrated, the experience at the University of Bedfordshire in the recent years shows that Project Management in general and risk in particular can be experienced within the safety of a virtual world. Various aspects of risk management are addressed in this type of assignment. We then argued that the nature of the virtual world, for instance if it is hosted within the institution, by a dedicated provider, or by the students play a significant role and imply differences on how risk is perceived by the students. Indeed an assignment that has started within Second Life cannot be moved so easily to a different provider – even if the technology that supports it is the same – as the difference in environment and hence immersion will change the nature of the students' perception and hence the 'situation' in which the students find themselves.

While the work presented here focuses on the development at the University of Bedfordshire the observations are relevant in a wider context. Situated learning is not only useful to Project Management but also to other disciplines with vocational learning goals. Even more, in view of the various Virtual World implementations interviews with educators from other institutions (Christopoulos and Conrad, 2013) do not identify a clear preference but seem rather ambiguous. Further research (including experimentation and a systematic student evaluation) is needed to identify how future Virtual Worlds should look like in order to provide an optimal environment for students to achieve a relevant learning experience.

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LINKS TO SOFTWARE

Second Life: http://secondlife.com
Reaction Grid : http://reactiongrid.net
OSgrid: http://www.osgrid.org
Dreamland Metaverse: http://www.dreamlandmetaverse.com
OpenSim: http://opensimulator.org/wiki/Main_Page

Identifying Learner's Engagement in Learning Games
A Qualitative Approach based on Learner's Traces of Interaction

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Abstract: This paper proposes a qualitative approach for identifying learners' engagement from their traces of interactions performed in the learning game. Learners' engagement is an effective indicator of their motivation, acceptance and attachment to the learning activity. Engagement also informs about the relevance of the content and the effectiveness of the proposed interactive learning game. Designers, practitioners and teachers need information about engagement for analysing, designing and validating the learning game and also for modifying and adapting learning games in order to maintain their effectiveness. Currently, most of the approaches provide quantitative information about learner's engaged-behaviours. Thus, our objective is to extract qualitative information from learners-generated data. In this paper, we propose an approach in three stages that combines theoretical works on engagement and engaged-behaviours, Activity Theory and Trace Theory. By relying on traces of interactions, this approach enables to identify engaged-behaviours in low-constraint interactive games, directly, continuously, under ecological conditions and over a long time period. Then we present the results of a user study that demonstrate the feasibility and the validity of our approach. This study has been conducted on twelve traces composed of several thousands of learner-generated data.

1 INTRODUCTION

The features of digital games like multi-sensory immersion, interactivity and immediate feedback stimulate students' motivation and facilitate the development of skills like attention, problem-solving, decision-making or collaborative work (de Aguilera and Mendiz, 2003). Several studies (Gee, 2003; Egenfeldt-Nielsen, 2006) argue in favour of the use of digital games as efficient educational tools. This explains why computer supported education practitioners show a growing interest in digital game based learning (Prensky, 2007).

Student's engagement is considered as a useful indicator in order to prevent school dropout (Reschly and Christenson, 2006). Identifying engagement may inform about learners' motivation, acceptance and attachment to the learning mediated activity. It can also inform about the relevance of the content and the effectiveness of the proposed interactive technology or service. These information may be used by designers and teachers for testing, modifying or adapting the content or features of the system. During classroom lessons, teachers have the opportunities to assess and influence students' engagement (Skinner and Belmont, 1993) by adapting the form or the content of the lessons according to several students' characteristics such as personality, motivation, needs and affective states. With computer supported education, the relationship between teachers and students is limited, especially in the case of distance learning (Greenhow et al., 2009). Two means are available for eliciting and maintaining learners' engagement in mediated learning activities: either the mediated activity is intrinsically engaging (this is what is expected with the learning games), or the teacher has some information about learners' engagement.

In this paper, we propose an approach for identifying learners' engagement in learning games from their traces of interaction (i.e. learner's actions actually performed within the mediated activity). This approach, useful for both teachers and designers, enables the direct and continuous analysis of students' engaged-behaviours under ecological conditions. We applied our approach through the analysis of 12 traces of interaction in a digital game.

This paper is organised as follow. In section 2 we refine the concept of engagement and review the methods for identifying it. In section 3 we describe the three stages of our qualitative approach. In section 4 we present the results of a user study and discuss them. Finally, in section 5, we conclude by showing the implications for computer-supported education and introduce some future works.

2 BACKGROUND AND RELATED WORK

In this section we study the notions of engagement. Our aim is to provide a definition that is applicable in both entertainment and learning fields. Based on this definition, we study the methods for identifying engagement in digital gaming.

2.1 Defining Engagement in Digital Gaming

(Boyle et al., 2012) observe in their systematic review on engagement in digital games, that the nature of engagement is still not well understood and that there is still a lack of a widely accepted definition of engagement. Defining an abstract concept like engagement is useful in order to facilitate scientific exchanges, especially when the concept is used in several fields. Also, it helps to be clear about what is aimed, or what is being measured. Thus, it improves the validity and effectiveness of the comparisons between several methods or approaches. (Brown and Cairns, 2004) define engagement as ”the lowest level of immersion” before ”engrossment” and ”total immersion”. (Brockmyer et al., 2009) consider engagement ”as a generic indicator of game involvement” which can evolve on a progressive scale whose levels are immersion (Jennett et al., 2008), presence (Tamborini and Skalski, 2006), flow (Csikszentmihalyi, 1991) and psychological absorption (total engagement).

In the field of education, engagement may be considered as the ”behavioral intensity and emotional quality of a person's active involvement during a task” (Reeve et al., 2004). After reviewing the concept of school engagement, (Fredricks et al., 2004) conclude that engagement is a ”meta construct” which encompasses ”behavioral” (participation, positive conduct, effort), ”emotional” (interest, positive emotions) and ”cognitive” (psychological involvement in learning, self-regulation) dimensions.

The first issue with these definitions is the reference to ambiguous concepts like *involvement* and *immersion*. The second issue is that these definitions are context-dependent (for example the definitions in the entertainment field seem to address more specifically the immersive games). As we aim to provide a definition that is valid in the both fields, we think more relevant to answer through a conceptual definition that focuses on the state of engagement rather than to its outcomes.

So we consider engagement as ”the willingness to have emotions, affect and thoughts directed towards and determined by the mediated activity”. Engagement occurs if players or learners' expectations (perceptual, intellectual, interactional) are fulfilled. Then, in a process similar to the *suspension of disbelief*[1] (Coleridge, 1969) players and learners may willing to get engaged in order to live more intensely the activity. Then they accept that, during a given time (perhaps beyond the duration of the mediated activity), their emotions, affect and thoughts will be mainly elicited by the mediated activity (here the digital game-based learning). The consequence of this engaged state, is that players' or learners' attention will remain on the game and their motivation will make them keep playing and coming back (again and again) in the game.

2.2 Identifying Engagement in Digital Gaming

Our objective is to analyse learner's engagement directly (i.e. from their actions and not a posteriori), continuously and over a long time period (i.e. session after session across weeks and months) and under ecological conditions (i.e. at home and without interfering with the learner's activity nor impacting the system). Our approach must allow to analyse the whole population of users rather than a selected sample and must be effective with interactive systems that offer a wide range of actions. Therefore, we do not address in this section psychophysiological or self-report, interview and observation methods (see respectively (Kivikangas et al., 2011) and (Fredricks and McColskey, 2012) for recent reviews).

Metrics approaches are used in industry and academics for meeting the previously mentioned con-

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[1] Suspension of disbelief is the willingness to accept, despite the technical or narrative shortcomings, a fictional work as being the reality.

straints. It consists in automatically collecting and storing any users' actions performed through input devices towards the system such as, users' choices, location changes, modifying character's characteristics, interaction with other character but also information like time spent or the level reached. Thus, it is possible to record all the users' course and process during the activity. Then, some data mining methods can be applied on these user-generated data in order to derive valuable (i.e. interesting, interpretable and useful) information. See (Romero and Ventura, 2010) for a review addressing specifically learner-generated data. As metrics only inform on what users are doing but not why, one may see a limit in aiming to identify engagement (i.e. an abstract quantity) from metrics (Canossa and Drachen, 2009).

As engagement influences the behaviour, some measurable quantities can be considered for identifying engaged-behaviours (Bauckhage et al., 2012). For studying the impact of tutorials on players' engagement in digital entertainment games, (Andersen et al., 2012) collect some raw data like the number of unique levels completed, the total playing time and the number of times players have loaded the game. Expecting to predict when players will stop playing, (Bauckhage et al., 2012) study how engagement evolves over time. They apply techniques from lifetime analysis on player's playing times information (when they play and for how long) collected from five AAA-games like Tomb Raider or Crysis. (Weber et al., 2011) study players' engagement in terms of player retention within an American football game. For that purpose they collect preference data such as the game mode selected and behavioural data like average yards gained or ratio of possession. Dealing with learner's disengagement detection in web-based e-learning system, (Cocea and Weibelzahl, 2009) compare eight machine learning techniques on several raw data. The latter are mainly related to reading pages (number of pages read, time spent reading pages) and quizzes events. The previous methods conduct quantitative measure on isolated (i.e. unlinked) data item. Thus, rather than addressing engaged-behaviour as a whole, they stay at a basic level by only considering some parts of an engaged-behaviour.

Some approaches are considering user's engaged-behaviour through some sequences of actions. (Beal et al., 2006) propose a classification approach of learner's engagement within a mathematics ITS. For that purpose, they defined five student's time-dependent patterns of actions based on time traces of actions within the ITS. More recently, (Köck and Paramythis, 2011) adopt a clustering approach for detecting sequences of learner's actions in the Andes ITS. These studies only occur in high-constraint environment like ITS. In such environments, the variety of actions is tight and fully determined by the interactive system (attempts, request for hint, results etc.). In this case the number of items is limited. Thus, sequence-mining may constitute an efficient method for discovering some statistically relevant sequences of actions. But, in low-constrained interactive systems like learning game, a wide range of actions may be possible. Then, sequence-mining could return a too large number of sequences. Also, as the temporal succession of actions does no imply that there is a coherence between these actions, these actions may be not useful in order to derive valuable information about a high-level engaged-behaviour. Moreover, machine learning for sequential data mining suffers from several issues like long-distance interactions (Dietterich, 2002). This can be problematic if, within an engaged-behaviour, a long period occurs between items.

3 AN APPROACH FOR IDENTIFYING ENGAGED-BEHAVIOURS

In this section we present our qualitative approach for analysing directly, continuously and under ecological conditions learner's engaged-behaviours in low-constraint interactive games and over a long time period. For that purpose we consider learner's behaviour as a chain of actions actually performed in the digital game. A chain of actions is an aggregation of learner's actions selected from temporal constraints and/or characteristics of the action. By aggregating several actions, we expect a comprehensive contextual information about learner's engagement. Also we adopt a theory-driven perspective by firstly determining some engaged-behaviours. Therefore, the challenge is to identify, among the wide variety of possible actions, those that are inherent to the engagement. These actions can refer to a high number of dimensions of the interactive systems and be collected at different granularity of temporal and spatial resolution. So, three main issues have to be overcome:

1. Determining some high-level engaged-behaviours.
2. Characterising these engaged-behaviours by identifying the underlying chains of actions.
3. Detecting these chains of actions among all the actions recorded.

Our strategy for tackling these three issues is in three stages. Each stage is described in the following three sub-sections.

3.1 Determining Engaged-behaviours

In this section we describe how we determine some high-level engaged-behaviours. To decide whether a behaviour reflects, or not, an engagement, we consider the question of the learners' motives and needs that determine engagement. This is useful in order to give meaning, in relation to their engagement, to users' actions.

(Przybylski et al., 2010) use the Self-Determination Theory (SDT) (Ryan and Deci, 2000) for explaining digital game engagement. The SDT identifies three basic psychological needs: *competence* (sense of efficacy), *autonomy* (volition and personal agency) and *relatedness* (social interaction). This perspective is different from other works based on empirical observations on players' behaviours. (Lazzaro, 2004) identifies four motivational factors for playing game labelled *hard fun* (challenge), *easy fun* (curiosity, fantasy), *altered state* (positive emotions) and *people factor* (social experiences). (Yee, 2006) observes three main components: *achievement*, *social* and *immersion*.

Even if these motivational factors are closed to the basic psychological needs previously mentioned. The basic psychological needs perspective has several advantages. As it is not based on empirical observation of players' behaviours on specific games, it does not depend on the gameplay[2] of the game. Thus, basic psychological needs perspective can be applied on all current or future gameplay. By being more versatile, this approach enables to determine a wide and non-stereotyped range of behaviours. Our aim is neither to determine a user model nor to provide a model of engagement but to identify some behaviours that significantly reflect learner's engagement (i.e. that are not determined by the gameplay of the learning game). Thus, for qualifying a behaviour of being engaged, we link users' behaviours to the universal needs identified by the SDT that they satisfied.

For structuring the analysis of engaged-behaviours, we consider that digital gaming consists in performing some *actions* (decision-making process), *directly or through a character*, within an *environment* (or at least on a frame) which may involve *social interaction* with human or virtual agents. Thus, the gaming activity has the following four dimensions: *environmental* (in relation with the *autonomy* need), *social* (in relation with the *relatedness* need), *self* (in relation with the *autonomy* need) and *action* (in relation with the *competence* and *autonomy* needs). Of course, according to the type of learning game (simulation game, computer supported collaborative learning), the components will not always be present, nor with the same intensity. Each component encompasses several engaged-behaviours including those observed by (Lazzaro, 2004) and (Yee, 2006). See Table 1 for an overall summary of the four components of players engagement.

3.1.1 Environmental Engagement

Player's engagement is directed towards the environment or the world depicted in the game. This engagement encompasses two main behaviours: the contemplation and the curiosity. Contemplatives like to stroll in the game area. Curious seek to know the physical and geographical boundaries of the game world. They may also be interested in configuring the features of the game. The goal is not to win but to increase their knowledge about the game.

3.1.2 Social Engagement

Social engagement refers to the social connections within the game. In this case, the game is an opportunity to create and expand social relations toward other players. The purpose is to develop and/or to maintain her/his social network. This player will massively use the communication channels provided, will promote the game to increase the number of participants, will enjoy teamwork (collaborative work in a serious game, within a team or guild in a digital game).

3.1.3 Self Engagement

Self engagement concerns the connection between players and their character through identification and/or ownership aspects. These players like to customize their avatar and choose accessories for some other reasons than performance. Players experiencing this type of engagement will be particularly involved in shopping stage (for a new sword, costume, skills etc.). Thus, they may spend a long time to study the characteristics of accessories or skills. This player will take care about the role play.

3.1.4 Action Engagement

Player's engagement is directed towards the actions to perform in the situation depicted by the game. The core of the game is the main interest for these players. Players will try to quickly pass the levels, to win experience points, to complete challenge etc.

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[2] In digital gaming, gameplay is a blanket term which refers to the structure, the dynamics or the interactive aspects of a game.

Table 1: Categorisation of (non-exhaustive) players' behaviours through the four components of engagement and some associated *activities*.

	Environmental engagement	Social engagement	Self engagement	Action engagement
Learner's behaviours	Contemplative Curious	Collaboration Competition Social relatedness	Managing an avatar	Surpassing oneself Enhancing skills
Activities	Virtual trip Trying to reach the limit of the game Discovering extra-content	Expanding social network Liven up the group of real friends Enjoyment with others	Customizing the character Developing a story around the character	Be a top scorer Completing challenges

3.2 Characterising Engaged-behaviours

The previous section on engagement enables to determine some engaged-behaviours by establishing the relationships between needs, motives and engaged-behaviours. This section describes how we characterise these engaged-behaviours. By characterising an engaged-behaviour we mean identifying the underlying actions and chains of actions performed by the learner within the learning game. Our aim is to select, among the various dimensions of the game, the relevant user-generated data i.e. the ones underpinning an engaged-behaviour. To reach this objective, we base on the Activity Theory to establish the relationship between the learners' needs, the object and motive of the activity and the actual realization of actions.

3.2.1 Basic Concepts of Activity Theory

Activity Theory (Vygotsky, 1978; Leontiev, 1978) aims to understand Human development through an analysis of the "genesis, structure and processes of their activities" (Kaptelinin and Nardi, 2006). Three different levels of analysis of the activity are distinguished :

- **Activity.** An activity is performed by a subject, through a tool, in response to a specific need or motive in order to achieve an object (objective). The need generates the motive, the motive elicits the activity, the object structures and directs (Kaptelinin, 2005) the activity towards a desired and *anticipated* (Bardram, 1997) outcome. Object is what characterises an activity and differentiates an activity from another (Leontiev, 1978). The object has to be of high significance i.e. be self-sufficient.
- **Action.** An action (or chains of actions) can be seen as the actual transcription of the activity. An action can be used by different activities in order to reach a goal. Thus, the goal of the action depends on the activity to which it is subordinated. The difference between objects (activity level) and goals (action level) is the significance. Actions are performed consciously and with effort through operations.
- **Operation.** An operation enables the actual realisation of the actions. Operations are automatized, that means performed without conscious thoughts or efforts. Operations are determined by the environmental and contextual *conditions* of the activity. Operations can be used by different actions.

3.2.2 Characterising Engaged-behaviours with Activity Theory

We use Activity Theory as a hierarchical framework for conducting a comprehensive and structured analysis of the engaged-behaviours within the learning game. This structuring tool enables to deconstruct an engaged-behaviour in *activity*, chains of *actions* and chains of *operations* actually performed in the interactive learning game by the students. So, within each components of engagement, activities share the same motive but have a different object. For example, the activities "*Expanding social network*" and "*Liven up the Group of Friends*" share the same motive (*Feeling emotions related to social interactions*) which is generated by the *relatedness* basic need but have different objects (respectively *Increasing the number of Friends* and *Maintaining a group activity within the Group*). In this, we comply with Kaptelinin's call (Kaptelinin, 2005) by distinguishing between *object* and *motive* of the *activity*.

Let's consider an example (illustrated on Figure 1) extracted from the user study presented in section 4. In the social engagement component we identify the *activity* : *Expanding social network* whose *motive* is *Feeling emotions related to social interactions* and *object* is *Increasing the number of Friends*. In our

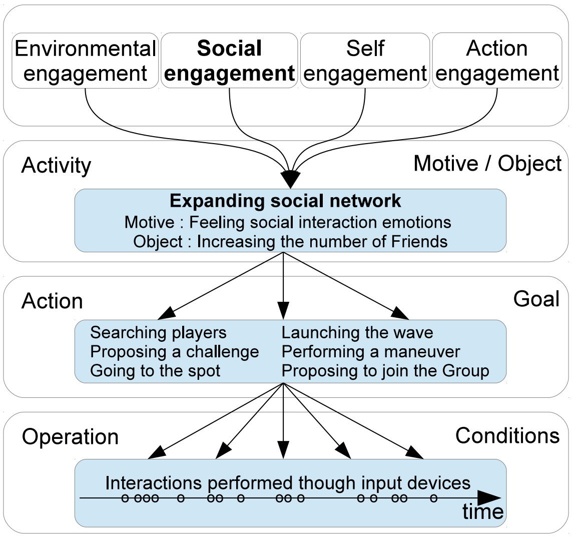

Figure 1: Social engagement in conjunction with Activity Theory hierarchy within the user study presented in section 4.

study this *activity* is deconstructed (i.e. supported) by the following *actions*:

- *Searching players living in a specific location*
- *Proposing a challenge to another player*
- *Going to the spot*
- *Launching the wave*
- *Performing a maneuver*
- *Proposing to join the Group of Friends*

All these *actions* are realised in the game through many *operations* actually performed with the input devices provided. These *operations* can consist in some mouse clicks or forms filling like for example typing the name of a town in the form for searching players or a button-pressed for launching a wave.

3.3 Detecting Engaged-behaviours

In section 3.1 we determine some engaged-behaviours. In section 3.2 we characterise these engaged-behaviours by deconstructing them in *activities*, *actions* and *operations*. This section describes the last stage of our qualitative approach based on the Trace Theory. The objective here is twofold. First we detect within the recorded learner-generated data the chains of *operations* identified in the previous stage. Then, we reify the relationship between *operations*, *actions* and *activities*. The objective is to extract the identified *activities* from the raw learner-generated data.

3.3.1 Concepts of Trace Theory

The trace analysis approach is a framework for collecting, organizing and using user's activity traces (i.e. any player's actions performed towards the learning game) (Clauzel et al., 2011). At the lowest level, there is the observed elements (labelled *obsels*). Typically, an *obsel* corresponds to a player's raw action collected in the game (like a mouse click or a key pressed on the keyboard). An *obsel* contains a type of event, a timestamp and a set of contextual information useful for characterising the event and to derive meaning. A primary trace is a set of *obsels* temporally situated which may be connected. A primary trace may contain a very large number of *obsels* whose informational level may be too low. So, it may be difficult to derive knowledge from a primary trace.

The formalization proposed by (Settouti et al., 2009) aims to facilitate the transition from primary traces to information that makes sense. This formalization uses a model of trace in order to organise and characterise the *obsels* within the trace. This model defines the types of the *obsels* and the types of the relation that compose the trace. It also considers a model of transformation which is a set of rules whose role is to transform a trace in a transformed trace of a higher level. A rule consists in temporal constraints or in operations on the contextual attributes performed between *obsels*. The transformed traces help to derive a more complex or abstract knowledge.

3.3.2 Detecting Engaged-behaviours with Trace Theory

We use the Trace Theory for addressing the third issue: detecting the engaged-behaviours among all the actions recorded. We combine Activity Theory and Trace Theory by establishing the following correspondences between these two theories:

- *operation* ⇔ primary trace composed of *obsels*
- *action* ⇔ primary transformed trace
- *activity* ⇔ highest-level transformed trace

Trace Theory enables to detect the relevant *operations* among all the stored *obsels* and then to reify (through the transformation process) the relationship between *operation*, *action* and *activity*. The *obsels* which compose the highest-level trace correspond to the *activities* that belong to a specific engaged-behaviour.

Lets consider an example illustrated by the Figure 2. During a session we collect many *obsels* from several types (i.e. which correspond to specific events such as asking another player to become friend,

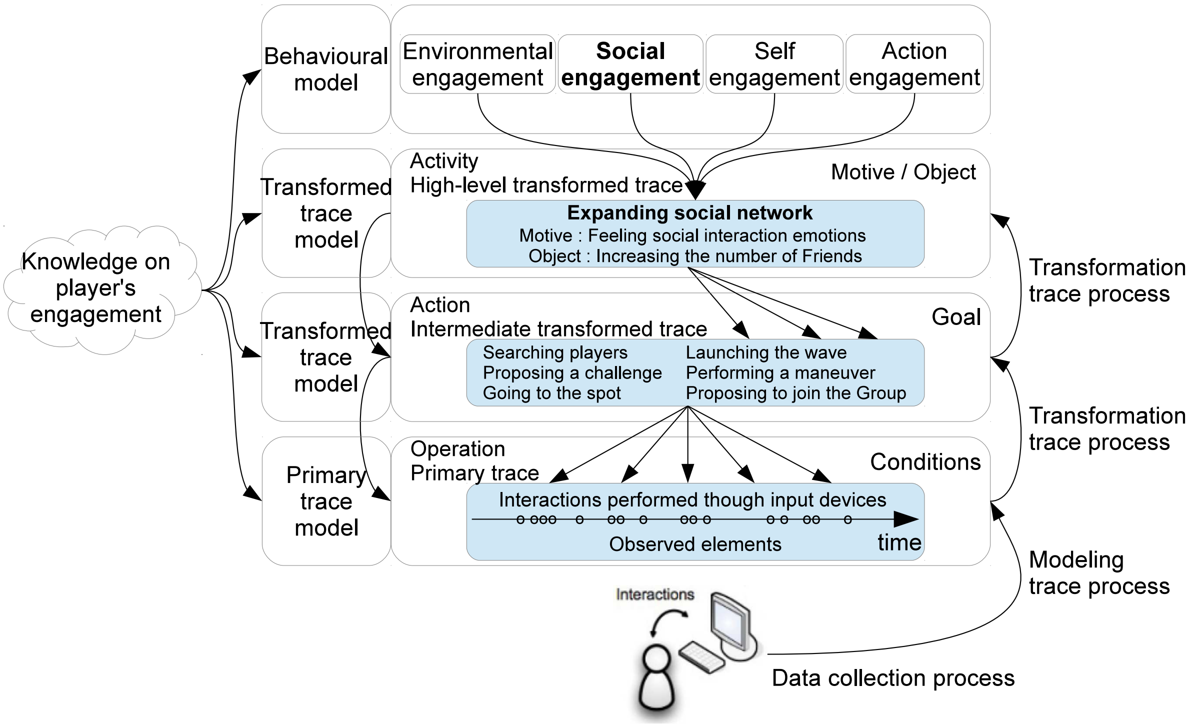

Figure 2: Our approach combines a theoretical work on engagement and engaged-behaviour, Activity Theory and Trace Theory for identifying engaged-behaviours from traces of interaction. An example extracts from the user study presented in section 4.

launching a wave etc.). We define a model of primary trace in order to organise and characterise the *obsels* within the primary trace. Then we also define a transformation model. In the latter we create a rule labelled *”Searching players by town”* (see section 4.2.2 for an example of rule). This rule enables to detect in the primary trace, according to some temporal constraints, the presence of the pair of *obsels* *”open the social search form”* and *”filling the players' town form”*. If they occurred within a certain time interval then the transformation rule generates a new *obsel* of higher-level (labelled *”Searching players living in a specific town”*) in a new transformed trace. The transformation model has also a rule labelled *”Proposing a challenge”* and so on. A second transformation model loads the previously generated transformed trace in order to generate the highest-level transformed trace. The latter may contain the *obsel* of highest-level that corresponds to the *activity* *”Expanding social network”*.

4 USER STUDY

The objective of our study is twofold. We want to verify (1) the feasibility of the whole process (i.e. collecting the user-generated data and determining, characterising and detecting some engaged-behaviours) and (2) the validity of our approach i.e. do the behaviours we detect reflect an engaged-behaviour?

We apply our approach on an online game. This game enables to work on a base of 150 000 active players per month and so on 150 000 traces. Also, this game enables to analyse engaged-behaviours in low-constraint interactive systems, directly, continuously and under ecological conditions and over a long time period. And finally the social and challenge dimensions are strong enough for providing a wide variety of engaged-behaviours. We first present the context of our user study. Then we detail the whole process for identifying some engaged-behaviours and present some results.

4.1 Context

For this research, we rely on the games developed by the company IntellySurf under the label YouRiding[3]. We consider the YouRiding Bodyboarding games which take advantage of the Unity[4] game engine. The Bodyboarding game consists in travelling

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[3] YouRiding: http://www.youriding.com

[4] Unity - Game Engine: http://unity3d.com

Table 2: Deconstruction of the *activity* Completing challenges in *actions* and *operations*. The *activity* Completing challenges is supported by the chain of actions To obtain information about the challenge – To improve the equipment – To improve the rider skills. The *action* To obtain information about the challenge is detecting through the *operations* game_open_profile_improvements and game_open_profile_skills.

Activity	Completing challenges			
Actions	Obtaining information about the challenge	Improving the character's equipment	Improving the character's skills	Paying for new credits
Operations	open_profile_improvements open_profile_skills	open_shop shop_buy_item shop_buy_with_cash open_profile_quiver item_equip item_repair	open_tricks open_key_config	open_bank process_bank

from spot to spot all over the world in order to select the most effective waves for performing some maneuvers (like tube ride), completing a challenge or challenging other players. Players have to detect when their character reaches the best zone of the wave to perform a maneuver (lip or tube of the wave etc.) with the right key combination. Players must also adopt the right strategy for trying only maneuvers that their character's skills and equipment can perform. Players should also make the right choices concerning the improvements of character's skill and equipment.

4.2 Implementation of our Approach

In this section we describe the implementation of our qualitative approach in the game used for the user study. We first show how we determine and characterise some engaged-behaviours. Then we explain how we detect these engaged-behaviours among all the interactions recorded.

4.2.1 Determination and Characterisation of Engaged-behaviours

This is the theory-driven part of the process for identifying some engaged-behaviours. In this example we consider the engaged-behaviour *Completing challenges*. The latter belongs to the Action Engagement component presented in section 3.1.4.

Then we characterise this engaged-behaviour through an Activity Theory perspective (see section 3.2.2). The table 2 details all the elements of this deconstruction. The analysis indicate that the *activity Completing challenges* is supported by the *actions Obtaining information about the challenge – Improving the character's equipment – Improving the character's skills*. A fourth *action Paying for new credits* is an option. Indeed, some players may buy some credits for improving their rider's equipment or skills. The *action Obtaining information about the challenge* is realized through the *operations* open_profile_improvements and open_profile_skills. These two *operations* indicate that the player has open the two pages that inform about the different challenges to complete.

4.2.2 Detection of Engaged-behaviours from the Traces of Interaction

We collect 89 types *obsels* (i.e. raw user-generated data raw) such as fb_link_account (a player connect her/his facebook account whith her/his account in the game), challenge_wait (a player propose a challenge) or goto_spot (a player go to a specific spot identified with its id) etc. The collect uses a classic client-server architecture with JavaScript and PHP scripts. The collect is automatically triggered when the player performs a targeted action (typically a click). The *obsel* is then sent to a server for being stored, session after session, in a MySQL database.

We use the tool D3KODE[5] (Champalle et al., 2012) for analysing the traces and defining the transformation rules (see section 3.3.1 on the Trace Theory). D3KODE provides the following features: loading the data as a primary trace, creating the models of transformation and the rules associated and a graphical visualization of the (primary and transformed) traces (see Figure 3 for an illustration). So, the data are exported from the MySQL database in a CVS (Comma-Separated Values) file that is compatible with D3KODE. Each line of this file contains two timestamps (the date and time of the beginning and end of the event, most of the time it's the same value), the name of the *obsel* and at most three attributes which may provide some contextual information such as the name of the button pressed, the identification number of the spot or of the equipment etc. Then we load the CVS file in D3KODE in order to obtain a primary trace.

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[5] Define, Discover, and Disseminate Knowledge from Observation to Develop Expertise

In order to visualise the *action* level we apply a transformation to the primary trace. This transformation is a set of rules that enables to aggregate several *operations* in order to generate a high-level *obsel*. A rule can rely on temporal constraints or on the contextual attributes. This high-level *obsel* corresponds to an *action*. For example the *obsel* open_profile_improvements and open_profile_skills are aggregated in order to generate the *action Obtaining information about the challenge*. The following rule enables to select the instances where the two pages Improvements and Skill have been opened during an interval of 2 minutes. The analysis of several traces of interaction indicates that players consult these two pages in this interval.

```
(
open_profile_skills.hasEnd < open_profile_improvements.hasBegin
(open_profile_improvements.hasBegin - open_profile_skills.hasEnd) <=120
)
OR
(
open_profile_improvements.hasEnd < open_profile_skills.hasBegin
(open_profile_skills.hasBegin - open_profile_improvements.hasEnd) <= 120)
)
```

We observe that the *action Obtaining information about the challenge* occurs many time for some players in their whole traces and never for other players. In a similar manner we create all the rules that enable to generate the four *actions*. And we iterate the transformation process for aggregating the *actions* and then generating the *obsel* of highest-level (i.e. the one that indicates the *activity Completing challenges*). In this case the temporal constraint may be larger as for example the *action Improving the rider's equipment* occurs less often than the *action Obtaining information about the challenge* .

4.3 Results

We collected twelve player's traces on the period from January to April 2012. These traces from engaged-players have been isolated by experts. A trace contains 89 types of *obsels* and can be composed of several thousands of *obsels*. We are able to detect 20 *actions* such as *Promoting the game towards facebook*, *Being interested in other players' information*, *Improving the equipment*, *Paying for new credits* etc. We identify six activities from the four components of engagement such as *Expanding social network*, *Animate facebook group of friends*, *Completing challenges* etc. These results show the feasibility of the whole process. This process is illustrated in Figure 3.

We also observe that the players who play the most (the sessions of play are spread over the whole period of four months) show several *activities* from several components of engagement. On the contrary, players who stop playing after only several sessions of play (typically spread on only one month) show no *activities*. This confirms that the behaviours we detect reflect an engagement. Also it seems to indicate that the variety of the performed *activities* is a relevant information regarding the engagement.

4.4 Discussion

Compared with a quantitative approach that would have done some statistical measures on the number of waves surfed by the player, our qualitative approach go beyond this information by identifying in which chains of actions a wave has been surfed. Indeed, we know if a wave has been surfed in order to complete a challenge or for challenging another player in order to be introduced with her/him.

For this user study we worked on twelve traces for implementing the transformation rules. The rules can be used on other players' traces of interaction from the game studied in this paper. Also theses rules could be applied to other digital games. From the designer point of view, the adaptability to various game engines would be fairly simple as few lines in JavaScript are needed in order to trigger the sending of an event. The *activities* and *actions* level, and the rules allowing to infer *activities* from *actions* are broadly shared by different types of games. For example, the *action Challenging another player* has the same meaning as soon as there is a confrontation between learners. But, the *operations* are determined by the design and interface of each game. Therefore, only the *operations* level and the rules allowing to infer *actions* from *operations* depend on the game. Also, the scalability (number of players, volume of collected data) comes to the Big Data issue. Thus, two points may be improved: the asynchronous transmission (but features of html5 such as WebSockets will facilitate it) and the storage (NoSQL databases are a promising solution).

We already have done some preliminary comparisons with a sequence-mining algorithm. In the traces we analysed, the four *obsels* goto_map, goto_zone, goto_spot and play_start_on_spot represent more than the half of the *obsels* that compose a player's trace. The results obtained with this algorithm mainly refer to sequences combining these *operations*. These are what we call trivial sequences are they are fully determined by the gameplay of the game. These re-

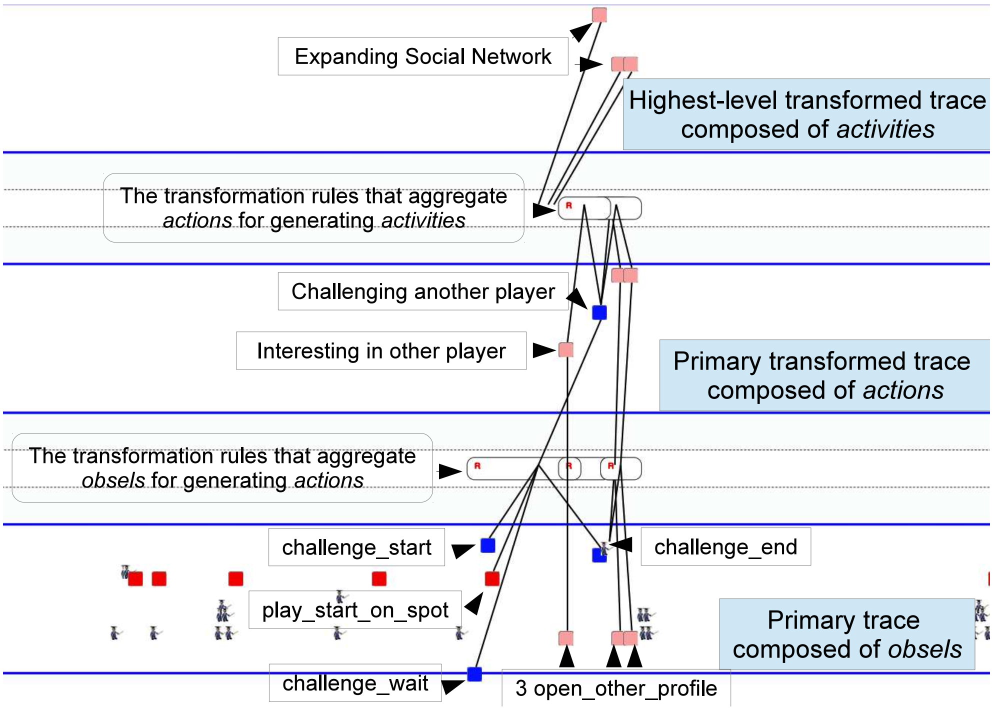

Figure 3: Graphical visualisation in D3KODE of the tranformation process from the *obsels* to a high-level engaged-behaviour.

sults seem to confirm the validity and effectiveness of our approach compared to sequences mining methods. This may be particularly true when the variety of actions within the interactive system is wide.

5 CONCLUSIONS AND FUTURE WORK

5.1 Summary of the Contribution

We propose a theory-driven and qualitative approach for identifying engagement from users' traces of interaction. This approach enables to identify engaged-behaviours in low-constraint interactive systems, directly, continuously and under ecological conditions and over a long time period.

For using qualitatively, rather than quantitatively, learners-generated data, we propose an approach in three stages: (1) determination of high-level engaged-behaviours, (2) deconstruction, from an Activity Theory perspective, of these engaged-behaviours in *activities*, *actions* and *operations*, (3) detection of the chains of actions among all the stored learner-generated data based on Trace Theory in order to extract the engaged-behaviours.

We present the results of our user study on twelve traces of interactions in order to demonstrate the feasibility of the whole process and to validate the approach.

5.2 Implications

Besides the psychological, physical, cognitive, social and cultural learner's factor, the effectiveness of the learning game depends on two categories of factors: the immersive and interactive features and the content (consistency and authenticity, narrative process, aesthetics) (Dondlinger, 2007). Our approach provides a structured tool for analysing the actual use of the game. The results may be different from designers' intuitions. It may also inform about what players want, what is missing in the game (like a wrong balance between the components of engagement). Thus, designers may modify the game in order to improve the player's experience.

Moreover, the process of engagement (Brien and Toms, 2008) (point of engagement, engagement, disengagement, reengagement) enables to deal with the aspect of temporality, i.e. how engagement evolves over time. Thus, the identification of learner's engagement during several sessions may be a useful information for teachers for maintaining engagement by adapting the content or the form of the learning activity. Also this information could be directly used by the interactive system for an automatic adaptation or for giving a feedback to learners.

We consider that engagement might be a concept easier to grasp and to identify than the user experience[6] in learning game. Thus, engagement and our approach for identifying it might provide a relevant information for designers, practitioners and teachers for analysing, designing and validating the learning game but also for modifying and adapting it in order to maintain the effectiveness of the learning games.

Also, our approach is not limited to immersive games like the one used for our user study. Indeed, our approach can be applied as soon as learners have some choices to perform (and thus there is some chains of action to analyse). Finally, this approach is not limited to engaged-behaviours and can be applied for identifying any evolution of behaviour from any type.

5.3 Future Works

Our approach is currently carrying out *a posteriori* and manually. But by conducting a regression analysis on players' actions, it could be possible to detect and then to select the most relevant (i.e. the most discriminant) activities and actions. Thus, by reducing the complexity of the calculations, it may be possible to automatise the method in order to identify engagement in real-time (i.e. during the mediated activity). The next step would be the automatic adaptation of the system to elicit and to maintain the engagement.

We plan to conduct a concurrent triangulation mixed-method by comparing and contrasting our results with subjective method like questionnaire or interview applied to ”real” players. We should also compare our qualitative results with quantitative statistical ones such as number and duration time of the playing session, payments done etc.

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[6] According to ISO 9241-210, user experience refers to ”a person's perceptions and responses that result from the use or anticipated use of a product, system or service”

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Automatic Test Item Creation in Self-Regulated Learning
Evaluating Quality of Questions in a Latin American Experience

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Abstract: The research area of self-regulated learning (SRL) has shown the importance of the learner's role in their cognitive and meta-cognitive strategies to self-regulate their learning. One fundamental step is to self-assess the knowledge acquired, to identify key concepts, and review the understanding about them. In this paper, we present an experimental setting in Guatemala, with students from several countries. The study provides evaluation results from the use of an enhanced automatic question creation tool (EAQC) for a self-regulated learning online environment. In addition to assessment quality, motivational and emotional aspects, usability, and tasks value are addressed. The EAQC extracts concepts from a given text and automatically creates different types of questions based on either the self-generated concepts or on concepts supplied by the user. The findings show comparable quality of automatically and human generated concepts, while questions created by a teacher were in part evaluated higher than computer-generated questions. Whereas difficulty and terminology of questions were evaluated equally, teacher questions where considered to be more relevant and more meaningful. Therefore, future improvements should especially focus on these aspects of questions quality.

1 INTRODUCTION

Learners are increasingly faced with a huge amount of knowledge and with new learning tasks that require abilities to improve the organization of their learning process. Therefore there is a shift from learning controlled by the teacher to a process where the students regulate themselves (Kroop et al., 2012). There is a relevant amount of research effort on student's self-regulated learning (SRL) strategies, mostly focused on highly controlled learning environments such as intelligent systems for tutoring, self-reflection, formative assessment and feedback (Zimmerman, 1989; Bannert, 2006; Nicol and Macfarlane-Dick, 2006; Conati and Vanlehn, 2000). Also there is a need to foster the students' SRL skills when they are not able to predict the output of a learning activity or the best learning path in virtual learning environments. Good SRL skills will help to adapt the learning process and improve the learning outcome. Therefore providing tools for continuous assessment and feedback is a key for the learning process. In this sense, in their introduction to assessment as a tool for learning Dochy and McDowell (1997) already pointed out how important assessment and evaluation are at all stages of a learning process. For a deeper understanding of a learning content reflection, feedback, learning path and an integration of learning and assessment are crucial elements. In SRL students often perform individual online searches regarding some learning topic and therefore their learning resources differ from those of their peers. In general, learning materials found in the web do not have integrated assessment tools (such as quizzes or short knowledge tests) and students are therefore not able to get feedback on their understanding of the materials. With an automatic question creation tool for natural texts, learners receive a possibility to generate their own little quizzes for any textual learning resource found in the web - independent of time, place, or the input of a teacher or tutor. Thus, they can deepen their understanding and learn more effectively by answering questions and obtaining feedback to their chosen learning context.

There has been extensive work on the idea of automatic creation of assessment items. One key component is the extraction and identification of the most relevant concepts used in natural language texts of the learning contents, still being a current research focus (Villalon and Calvo, 2009). There are a variety of experiences for automatically or semi-automatically generated test items from a given input text (e.g. Stanescu et al., 2008; Liu and Calvo, 2009). As an example, Liu and Calvo (2009) provided a tool that is capable to generate open-ended questions out of essays. Chen, Aist and Mostow (2009) created a tool that generates also open-ended questions but from informational texts. According to Agarwal, Shah, and Mannem (2011) the two main challenges in automatic test item generation are (a) to identify a content for which an item should be created and (b) to find a corresponding test-item type. Most research in this field deals with only one type of test item (mostly open-ended or multiple choice) generated for one specified content, e.g. a given sentence (Goto et al. 2010). Exceptions are for example Brown, Frishkoff, and Eskenazi (2005), who generated multiple choice and assignment items for vocabulary assessment or Myller (2007), who used multiple choice, single-choice, and open ended questions in his work on prediction questions for visualizations. Guetl, Lankmayr, Weinhofer, & Hoefler (2011) have developed a tool which generates four types of questions out of natural text.

In our proposed approach, a learning environment scenario enables students to read a text, then select key concepts from this text, and finally get an automatic assessment that will help to improve their understanding and knowledge acquisition. The test items are either based on the concepts selected by the student or on concepts extracted by the tool itself. We used the EAQC by Guetl et al., (2011) integrated in an online learning environment (Intelligent Web Teacher, IWT, by Capuno et al., 2009) to generate test items for two different topics. EAQC has already been evaluated with several quality criteria (Hoefler et al., 2011; 2012). However, previous studies were set up as stand-alone experiences with undergraduate students as participants and no direct involvement of the teacher. To test the quality of the EAQC in a more realistic, broader, and more discerning setting, this study was carried out in Guatemala with participants from different countries in Latin America. Students were enrolled in a full online SRL course and are for the most part teachers with different cultural background. Furthermore, EAQC test items were compared to items generated by participants' actual teacher. The main goal of the study was to evaluate the quality of the concepts and questions generated with the EAQC.

This paper is organized as follows: after a description of the EAQC and IWT tools, the research methodology including participants, instruments used, and the experimental design, is presented. The next section reports the results, which are followed by a discussion and final conclusions.

2 THE ENHANCED AUTOMATIC QUESTION CREATION TOOL (EAQC)

The Enhanced Automatic Question Creator EAQC (Guetl et al., 2011) is a tool that automatically creates test items from textual learning material. EAQC has the functionality to generate different types of test items from textual input. The item types supported by the EAQC are: open end (OE), multiple choice (MC), true or false (TF), and fill-in-the-blank (FiB) questions. EAQC processes the textual input, which can come in a diversity of file formats, then extracts the most important content from the text provided and performs a relation of concepts. EAQC creates the different test items and also creates reference answers. The EAQC architecture provides a flexible extension to multiple languages, an important feature to test the tool with international scenarios. Furthermore, the EAQC is capable to export the test items in a standard compliant format (e.g. IMS Question and Test Interoperability QTI).

EAQC supports mainly the following scenarios: First, a totally automatic question creation scenario where students and teachers cannot control the assessment authoring but they only select the learning materials. Second a more interactive setting where students and teachers can select not only the learning material but also they can tag and select concepts using an online editor. These concepts are used for creating the questions, which finally results in an assessment that has been created automatically, but is based on users' selection of relevant concepts. The generation of questions in EAQC can be divided into two processes. In a first step, the EAQC extracts concepts out of the text, which can be viewed by the user. In a second step, questions are generated based on the extracted concepts. Therefore, the user can choose which concepts are to be used for the generation of questions, and which types of questions are to be generated (e.g. two multiple choice, three true/false questions, etc.). The generated questions are presented as test to the user and right after taking the test, students receive feedback on their performance. Thereby, the EAQC lists again all questions but this time with the answer given by the student, the correct answer, and the received points.

2.1 The e-Learning Platform (IWT)

The EAQC was used by the students within the Intelligent Web Teacher (IWT) platform. IWT provides flexibility and extensibility characteristics for contents and services at a low level and for strategies and models at a higher level (Capuano et al., 2009). Furthermore, IWT platform provides easy to adopt didactic experiences based on user preferences for a personalized learning.

The EAQC was integrated into the IWT after previous studies (Al-Smadi et al., 2011; Hoefler et al., 2011; 2012) and further improved with two new features. These features were the implementation of a function for adding concepts and other function for tagging concepts. To add new concepts in the tool, the user open the list of concepts the EAQC extracted from a text and then is chooses further concepts from a list of words and phrases contained in the text. Furthermore, the user can order the final list by relevance and choose only the most relevant concepts to generate questions. The function for tagging concepts allows students to simply highlight a concept within the text and then save it to their concept list. Afterwards, they can generate questions on the basis of their self-extracted concepts.

3 RESEARCH METHODOLOGY

3.1 Motivation and Goals

The main goals of this study were (a) to systematically test the quality of concepts and questions generated with EAQC by comparing them to those generated by a real teacher (with course material used in an actual learning setting), and (b) to provide an automatic assessment tool that motivates and supports students in a SRL environment.

3.2 Participants

The experiment was carried out in the Institute Von Neumann (IVN) of Galileo University, Guatemala. IVN is an online higher education institute.

Thirty students enrolled in a course on "Learning models and processes for e-Learning" participated in the study. From these students, 27 were from Guatemala, 2 from the United States, and 1 from Colombia. The course is part of a complete online learning Master degree program in "e-Learning Management and Production". The students are university professors, consultants and instructors at corporations.

Twelve students were male and 18 were female. Participants were between 22 and 48 years with an average of 36 years (SD = 10.45). Concerning the highest level of education, 11 students finished their Bachelor, 16 held a Master's degree and 3 a PhD. Participants' native language was Spanish, but they indicated (on 5pt.-rating scales) that they had good writing (M = 3.57, SD = 0.84) and reading (M = 4.13, SD = 0.72) skills in English. Participants were familiar with e-learning environments (M = 4.43, SD = 0.63) and slightly preferred online-courses over face-to-face courses (M = 3.57, SD = 0.94). Students gave their consent to participate in the study by filling out the first out of four questionnaires.

Due to their enrollment in the master degree program, all students had already acquired basic skills for online learning. The activities for this study were introduced by the course professor (teacher) to increase students' motivation for fulfilling the required tasks (Ko and Young, 2011).

3.3 Experimental Design

One main goal of the study was to test the generated questions quality with a balanced design covering the following aspects: The first factor concerns the question type and comprises the three factor levels multiple choice (MC), true or false (TF) and fill-in-the-blank (FiB) questions. Open ended questions were not included, because the automatic assessment cannot account for different wordings. The second factor refers to the creator of the concepts on which the questions are based on and has two levels, teacher and EAQC. Hence, the concept is either extracted by the teacher or automatically by the EAQC. The third independent variable refers to the creator of the questions. As the question is either generated by the teacher or by the EAQC, there are also the two factor levels, teacher and EAQC. Thus, the evaluation of the questions' quality is based on a 3 x 2 x 2 design. All questions were presented for two learning contexts, namely Problem-based learning and Project-based learning.

The dependent variables concern the quality and difficulty of the questions and their respective answers. The following evaluation criteria have already been applied by Hoefler et al. (2012) and go back to the work of Cannella et al. (2010). Quality of questions is measured by the four aspects pertinence, level, terminology, and difficulty. Pertinence denotes the relevancy of a question with respect to the topic. Level addresses whether a question is trivial or expresses a significant meaning. Terminology focuses on the appropriateness of the words chosen and difficulty refers to the perceived difficulty of a question. Quality of answers is measured for FiB and MC questions by means of the aspects terminology of the correct answer, ambiguity of the answer, and for MC questions also by the quality of the given distracters. For both, question and answer quality mean scores were calculated from the 4 respectively 2 (or 3) single aspects. All aspects were evaluated by the participants on 5-pt. rating scales with 1 indicating a low quality and 5 indicating a high quality (except for ambiguity, where 5 indicates high ambiguity and therefore low answer quality). According to the experimental design, we calculated a multivariate ANOVA with three factors.

Regarding the concepts extracted from the two learning contexts, we differentiated between teacher, EAQC, and student concepts. To evaluate the quality of these concepts participants rated their relevancy on a 5pt. rating scale.

3.4 Research Instruments and Procedure

During the self-regulated learning experiment, participants had to read two texts, extract concepts from these texts, take knowledge tests, and fill out four questionnaires. The questionnaires which were presented via Lime Survey, an open source survey application tool (see http://www.limesurvey.org/). It took five weeks to carry out the entire study starting with the selection of learning material until the presentation of the last questionnaire.

The two texts were provided by the teacher of the course and concerned the topics “Problem-based learning” and “Project-based learning”. They had 1307 and 1002 words respectively and dealt with basic knowledge (definition, history, theoretical foundations, etc.) on the two topics.

The experiment consisted of four phases (Phases 1 – 4). The first phase took place before the students started working on IWT. In this pre-phase students were asked to fill in a pre-questionnaire (Q1), which covered the following sections: demographic data, previous knowledge regarding e-learning, general questions about learning preferences, evaluation of question types, and students’ English skills. Furthermore, in Phase 1 the two learning resources were selected by the teacher. For both texts the EAQC and the teacher extracted 10 concepts each and put them in an order of relevance. For each topic, the extracted concepts were collected in an evaluation questionnaire (Q2), which was given to the students in Phase 2 in order to evaluate the concepts’ relevancy. In the case of equivalent concepts, the next one in the order of relevancy was chosen. The 20 concepts in each questionnaire were randomized, i.e. students did not know which concepts were extracted by the EAQC and which ones by the teacher. Hence, we could check whether the quality of the EAQC concepts is as good as the quality of the teacher’s concepts.

For the second phase students were assigned to two groups (Group 1 and Group 2). First, each group was asked to read one learning resource presented via IWT. Group 1 read the text on Problem-based learning, Group 2 the text on Project-based learning. Second, the students, in this phase, had to extract at least 6 concepts from the text by tagging and highlighting keywords. Additionally they were asked to put their concepts in an order of relevance. At the end of Phase 2 students answered the evaluation questionnaire Q2 with the teacher and EAQC concepts concerning the learning resource they had just read before.

In the third phase of the study questions based on the 20 concepts extracted in Phase 1 were generated by the teacher and the EAQC as follows: For each learning resource, the teacher was asked to generate one question for each of the six most relevant concepts extracted and ordered by herself and by the EAQC, four teachers’ and EAQC concepts were discarded. The only constraint was to use each questions type (MC, TF, FiB) twice for the teacher as well as for the EAQC concepts. Thereafter, the EAQC questions were generated for the same 12 concepts under consideration of the question type chosen by the teacher. Thus, we obtained two parallel questions for each concept. This approach was taken to make sure that for each concept a suitable question type was chosen and to ensure a fair comparison of teacher and EAQC questions.

Summarized, for each learning resource, 24 questions (12 teacher / 12 EAQC questions) based on 12 concepts (6 teacher / 6 EAQC concepts) were generated. This resulted in four different variants of questions: teacher questions based on teacher concepts, teacher questions based on EAQC concepts, EAQC questions based on teacher concepts, and EAQC questions based on EAQC concepts. Combining the four question variants with the three types (MC, TF, FiB) yielded 12 different sorts of questions. From these questions the evaluation sections of Q3 and the knowledge tests for Phase 4 were constructed. For each topic, two parallel test forms were created and students were assigned to 4 groups (Group A, B, C and D). Students from Group 1 were assigned to Groups A and B, Group 2 was divided into Group C and D. Each pair of groups received parallel test and evaluation forms. Group A for example received a teacher question based on the first concept and an EAQC question based on the second, whereas Group B received those backwards, and so on.

Phase 4 was the second unit with students working in the IWT. First, students learned the text on IWT, which they had read in Phase 2. Second, they were asked to extract six concepts as in Phase 2 in order to compare consistency of the extracted concepts. Then, the students should generate "on-the-fly" questions from the EAQC based on their self-extracted concepts. After that, students received the knowledge tests created in Phase 3 about the text, they had just learned before. Groups A and B received the parallel tests on Problem-based learning, and Groups C and D the tests on Project-based learning.

After this, the students switched topics and read through the other learning resource. Groups A and B read the text on Project-based learning, and Groups C and D the one on Problem-based learning. Then, the students received Q3, in which they were asked to evaluate (a) the tool's usability, (b) the 10 most frequent student concepts extracted by their peers in Phase 2, and (c) the 12 questions generated by the teacher and the EAQC. Groups A and B evaluated the concepts and questions regarding the text Project-based learning, Groups C and D the concepts and questions related to Problem-based learning. Thus, Groups A and B evaluated the concepts extracted by students which were in Group C or D and the questions which Groups C and D had received in their knowledge tests and vice versa.

Finally, after students had finished their tasks in Phase 4, a post-questionnaire (Q4) was sent out concerning their motivation during the study. It contained the subscale "Task Value" from the MSLQ by Pintrich et al. (1991). This scale measures students' perception of the course material in terms of interest, importance, and utility. High task value should lead to more involvement in one's learning outcome and Pintrich et al. (1991) found a high correlation between task value and intrinsic goal orientation (r = .68). More specifically, students have to indicate their (dis)agreement to six questions regarding the task value. Furthermore, Q4 contained questions regarding students' motivation to do the different tasks involved in the study, e.g. reading the texts, extracting concepts, or working with the IWT. Answers were given on a 5pt. rating scale ranging from (1) not motivated at all to (5) very motivated.

Additionally, a post-questionnaire for the teacher was provided, which included questions on the usability of IWT, emotional aspects, and some open questions. We used the SUS (System Usability Scale) by Brooke (1996) in order to investigate the tool's usability. For the emotional status of the participant we added a scale (Computer Emotion Scale) by Kay and Loverock (2008) developed to measure emotions related to learning new computer software, describing four emotions: Happiness, Sadness, Anxiety and Anger.

4 RESULTS

From the 30 participants filling out the pre-questionnaire (Q1), 25 took part in Phase 2, in which they evaluated the relevancy of 20 concepts extracted by the teacher and EAQC. In Phase 4, we collected data from 20 participants, who all evaluated 10 student concepts and the 12 questions created by the teacher and EAQC. The knowledge tests which also contained the EAQC and teacher questions were taken by only 13 students. The data of one student was not included in the analysis below, because she called and saved the test, but did not answer a single question. Thus, for each of the two topics, six students took the prepared knowledge test. Furthermore, four students took an on-the-fly test with a total of 21 generated questions (seven for each question type).

The two texts were not chosen by the experimenters, but by the teacher of the course herself. Independent samples t-tests performed for concept relevancy (RelConc), mean question quality (QualQu), and mean answer quality (QualAns) yielded no differences between the two topics Problem-based and Project-based learning (RelConc:$t_{(68)}$=.155, p=.877; QualQu:$t_{(238)}$=.715, p=.475; QualAns:$t_{(158)}$=.243, p=.808). Thus, for the following statistical analysis the data were aggregated across the two topics.

4.1 Relevancy of Extracted Concepts

One important requirement for the generation of high quality questions is the extraction of relevant concepts within a given context. Thus, in Phase 2 of the experiment (see Section 3.4) the 10 most relevant concepts extracted by teacher and EAQC were given to the students to be evaluated (Q2). Additionally, 10 concepts extracted by the students in Phase 1 were presented to the other half of students in Phase 4 (Q3) and also evaluated with regard to relevancy. Thus for the comparison of EAQC and teacher concepts paired samples are available, whereas comparisons with student concepts involve independent samples. Figure 1 shows the average ratings for the three concept types for each topic. Across the topics mean ratings, teacher concepts, from 25 (for teacher and EAQC concepts) and 20 (for students) had the best rating over 4.12 (SD = .44).

A one-way ANOVA for the three concept extractors showed a significant effect ($F_{(2,67)} = 3.66$, $p = .031$). Post-hoc tests after Scheffé's method revealed a difference between teacher and student concepts ($p = .032$) but not between EAQC and teacher or student concepts ($p = .353$ and $.42$ respectively). Since teacher and EAQC concept evaluations are based on the same sample, we also performed a repeated measures t-test for a stricter comparison of these ratings; however, with $t_{(24)} = 2.0$ and $p = .057$ EAQC concepts do still not differ significantly from the concepts extracted by the teacher. Thus, it can be stated that concepts extracted from the EAQC are as relevant as concepts extracted by humans.

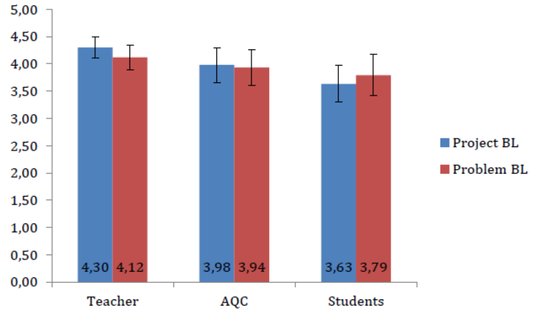

Figure 1: Relevancy ratings for concepts extracted by EAQC, teacher, and students.

4.2 Quality of Questions

To evaluate the quality of questions 3x2x2 MANOVAs were performed by aggregating the data from both topics (Problem-based and Project-based learning).

With 20 students performing the evaluation and 12 questions per student, 240 answers were collected for each criterion. These are divided equally over the question types (80 data points for TF, MC and Fib questions each), concept extractors (120 from teacher and EAQC each), as well as question creators (also 120 from teacher and EAQC each).

The evaluation metrics consisted of four measures for the quality of the questions themselves (pertinence, level, terminology, and difficulty) and two and three measures for the quality of the answers of FiB and MC questions (terminology of answer and ambiguity of answer for both, plus quality of distractors for MC). Since TF questions are not included in this analysis, the number of data points for answer quality decreases to 160 (80 for distractor quality). Figure 2 shows the mean ratings for question and answers quality per question variant (concept extractor x question creator) and question type (TF, MC, FiB). Because of the different numbers of questions types (TF, MC, Fib) involved, we performed two 3x2x2 ANOVAS for mean questions and mean answer quality.

The results are summarized in Table 1. Whereas none of the three factors had an effect on mean answer quality, we found one significant effect on mean question quality. More specifically, with $M_{teacher} = 3.57$ and $M_{AQC} = 3.32$ (SE = .063) questions created by the teacher were evaluated significantly higher, than those created by the EAQC. However, with a partial eta² value of .034 the effect size is rather small. Interactions are also non-significant. To investigate, in which aspect the questions differ, we had a closer look at the different aspects contributing to question (and answer) quality.

A three-way MANOVA including the four aspects of question quality yielded the expected effect of question creator for the multivariate results ($F_{(4,225)} = 2.51$, $p = .043$, $\eta_p^2 = .043$) and no other main effects or interactions. Univariate results showed that the effect is due to higher evaluations of teacher questions' pertinence and level. For pertinence teachers questions reached a mean rating of $M = 3.95$ as compared to $M = 3.58$ for EAQC questions with $SE = .092$ ($F_{(1,228)} = 7.82$, $p = .006$, $\eta_p^2 = .033$).

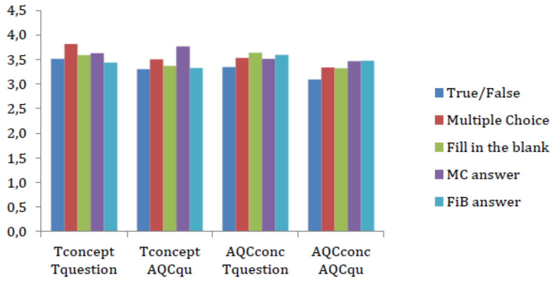

Figure 2: Mean rating for question and answer quality of T/F, MC, and FiB question (Tconcept = concept extracted by teacher, EAQCqu = question created by EAQC, etc.).

Table 1: Effects from three-way ANOVAS on mean question and answer quality.

	Factor	*df*	*F*	*p*	η_p^2
Mean question quality (*N* = 240)	Question Type	2,228	2.432	.09	.021
	Concept extractor	1,228	2.399	.123	.01
	Questions creator	1,228	8.025	.005	.034
Mean answer quality (*N* =160)	Question type	1,152	1.084	.299	.007
	Concept extractor	1,152	.044	.834	.000
	Question creator	1,152	.070	.792	.000

Ratings for level imply that teacher questions are more meaningful (M = 3.62) than EAQC questions (M = 3.27, SE = .096), with $F_{(1,228)} = 6.56$, p = .011, $\eta_p^2 = .028$. However, for both aspects the effects are only small in size. Ratings for questions' terminology and perceived difficulty did not differ significantly, and there were no significant interactions among the three factors.

With respect to the quality of answers, a closer look at the three aspects revealed no significant effects and no interactions for the multivariate results of the performed MANOVA (for MC and FiB questions), for the aspect terminology of the answer, and for the quality of distracters (ANOVA for only MC questions). However, we did find an effect of question type on the ambiguity of answers. With M = 2.35 (SD = 1.17) for MC and M = 2.8 (SD = 1.26) for FiB questions, participants evaluated answers of the latter question type to be more ambiguous.

The results presented in this section clearly show that the answers to the questions provided from the tool are relevant. Moreover, participants evaluated the quality of answers generated by the EAQC as equally high as the quality of answers generated by the teacher. By using teacher concepts for half of the questions created by the EAQC, we could also show that the tool is able to generate questions from concepts entered by users. Regarding the question whether all types of questions generated from the tool are as high in quality as questions generated by humans, the answer is two-fold. Whereas the quality of answers, the terminology, and the perceived difficulty of EAQC questions are evaluated equally high as those of teacher questions, the level and pertinence of questions received lower ratings. Thus, teacher questions seem to be less trivial and address the topic in a more meaningful way.

4.3 Difficulty of Questions

To further investigate if all types of questions generated from the tool are as high in quality as questions generated by humans, we also collected data concerning the real difficulty of questions. Therefore, the same questions which were presented for evaluation were also prepared as knowledge test and uploaded to the courses in the IWT. To avoid an influence of the evaluation process on the test taking or vice versa, each test was given to half of the students as test and to the other half for evaluation purposes. Whereas 20 students did the evaluation of questions only 13 took the knowledge test. Data of 12 students who each answered 12 questions could be analysed. All together 45.83% of the questions were answered correctly, which equals 66 out of 144 questions. Table 2 gives an overview on how many items per questions variant have been answered correctly. Since there is no difference between the topics Problem-based and Project-based learning (32 vs. 34 correct responses), the data are aggregated across the two topics. We calculated χ^2 tests to compare the frequencies for questions that (a) are based on EAQC vs. Teacher concepts, (b) are generated by EAQC or teacher, and (c) are designed as either TF, MC, or FiB question. Except for the question type, the critical χ^2 values exceeded the empirical ones. With $\chi^2 = 22.46$, the differences between the three question types are statistical significant, which can clearly be attributed to the very low solution rate for fill-in-the blank questions (8% correct solutions compared to 69% for MC and 60% for TF).

To investigate the relationship between perceived difficulty of actual difficulty, we correlated the mean ratings and number of correctly solved items per questions variant (i.e. for 12 different item types, as e.g. TF with teacher concept and teacher questions or MC with EAQC concept and teacher questions, etc.). The resulting correlation of $r_{(12)} = -0.71$ (p = .009) indicates that questions which are perceived as more difficult are also solved by less participants.

We also looked at the difficulty of the on-the-fly questions. From seven questions per type, five TF, six MC and 1 FiB have been answered correctly, which is in line with the findings reported above (high difficulty of FiB, no difference between TF and MC).

Table 2: Number of correctly answered questions per question type.

	Teacher concept		AQC concept		
	Teacher questions	AQC question	Teacher question	AQC questions	
TF	9	6	11	3	29
MC	0	15	6	12	33
FiB	2	0	0	2	4
Sum	11	21	17	17	66
Sum concept	-	32	-	34	
Sum question	-	-	28	38	

4.4 Usability of the EAQC Integrated in IWT

The basis for the validity of usability measures is the time participants spent in the system. Log data show that students accessed the IWT on average 3.31 times (SD = .72, MIN = 1, MAX = 7) and spent M = 103.78 min (SD = 89.3) within the system. The teacher (and her assistant) spent together 39 hours 28 minutes in the IWT, accessing it 102 times.

To evaluate the usability of the integrated EAQC, the SUS scale (see Section 3.4) was presented to students as well as the teacher. Students' mean SUS scores amount to 57.59 (SD = 16.99) with a rather large range from 23.75 up to 87.5. The SUS score provided by the teacher was 48.13. Thus students perceived the usability of the EAQC integrated in the IWT very differently, but on average higher than the teacher. However, both student and teacher scores are below the average of 68, which is the reference value suggested by Brooke (1996). Despite the low SUS score and the great amount of time the teacher spent in the IWT, ratings from the Computer Emotion Scale (see Section 3.4) show very positive emotions while working with the system (mean scores for happiness/sadness/anxiety/anger in the given order are 3/1/1.25/1).

4.5 Motivational Aspects and Task Value

To evaluate whether the tool had a positive impact on users' motivation concerning their learning, an analysis with results from 14 students filling out the post-questionnaire is presented. A requirement for having a positive impact on students' motivation is that they are generally comfortable with SRL settings. Participants of this study indicated that they like SRL environments (M = 3.77, SD = .76) and that they prefer learning on their own over being supervised all the time (M = 3.8, SD = 1.01). Furthermore, they agreed on the statements that testing themselves helps when they learn something (M = 3.87, SD = .72) and that they need clear instructions when they learn something (M= 3.93, SD = 1.03). These results are in line with the comments on the tool itself, namely that they liked the EAQC and automatic assessment as well as the possibility to highlight and save important concepts to support their learning process.

The task value scale by Pintrich et al. (1991), which was presented in the post-questionnaire showed that students were highly interested in the task and also perceived it as being important and useful. Mean ratings to the six single questions ranged between 4.5 (SD = .65) and 4.71 (SD = .47) resulting in a mean task value of 4.58 (SD = .48). Due to the high correlation of task value and intrinsic goal orientation reported above, it can be assumed, that students were also intrinsically motivated and involved in their learning activities. This result is also supported by the high motivation ratings for the single tasks required during the study, which ranged between 3.77 (SD = 1.01) and 4.31 (SD = .85). Figure 3 shows the mean ratings for task value and motivation for doing different task.

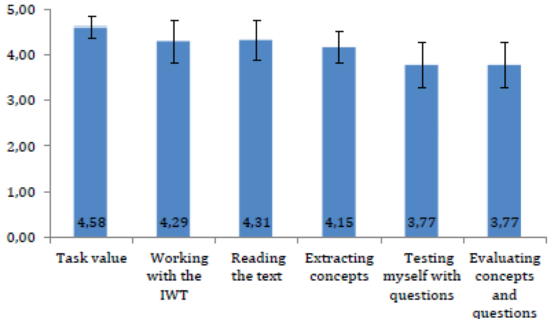

Figure 3: Mean task value (MSLQ) and level of motivation for various tasks.

4.6 Support of Self-regulated Learning

To investigate the pedagogical and psychological impact of the tool, we checked, whether the tool supports self-regulated learning and students can thus benefit from using the tool. According to the teacher the tool constitutes a support for students in the self-study process. From a teacher's point of view, the functions tested by the teacher were too few to judge the worth of the tool for teachers.

From student's point of view, testing themselves with questions had a positive impact on their learning activities (M = 4.43, SD = .76), taking the course improved their understanding of domain concepts (M = 4.5, SD = .65), and the course was a worthy educational resource (M = 4.43, SD = .76). In their open comments, all 14 students stated that they would benefit from self-assessments (self-generated tests) when learning in general. More specifically, they said, that self-assessments are a good preparation for real assessments, that they help to know one's level of knowledge or progress, and that it helps to improve the understanding and retention of concepts. Only one student indicated that he wouldn't go through a self-generated test, because for him reflection on his knowledge is more important. Another student stated that the self-assessments help to study a text, but that the questions were not good.

5 CONCLUSIONS

The aim of the conducted study was to evaluate a tool for automatic question creation (EAQC) and its application within the IWT. All questions generated by the EAQC are based on concepts, which are in a first step automatically extracted from a given text. In a second step the EAQC creates for each concept the required types of questions (up to four different questions per concept). Thus, the quality of the extracted concepts is an important factor for the achieved quality of the generated questions.

In this study the teacher of an online course on e-learning provided two texts and extracted the 10 most relevant concepts out of each text. Simultaneously, the EAQC extracted concepts out the same texts and put them into an order of relevance (see Section 3.4). We compared the relevancy of concepts extracted by the EAQC, by the teacher, and by students. The obtained results show comparable quality of automatically and human (teacher and students) generated concepts. Thus, we can conclude that the tool is able to extract relevant concepts from a text, which form a suitable basis for knowledge questions.

The quality of questions and their respective answers was evaluated by comparing it to the quality of questions created by a teacher (both EAQC and teacher questions were based on an equal number of EAQC and teacher concepts). A three-way MANOVA including the factors questions type (TF, MC, FiB), concept extractor (teacher, EAQC), and question creator (teacher, EAQC) revealed an effect of question creator for the dependent variables pertinence and level. Thus, EAQC questions are equally well formulated as teacher questions (no effect on terminology) and are perceived as equally difficult, but they are evaluated as more trivial and less relevant than teacher questions.

However, considering that the factor "question creator" accounts for only about 3% of the overall (effect and error) variance (η_p^2 =.033 and .028 for the two measures) and that the EAQC is mainly meant as tool to support self-regulated learning, the outcome of the evaluation is definitely positive.

Results from the evaluation of answers revealed no difference between teacher and EAQC terminology, ambiguity, or distractor quality. The same is true for the actual difficulty of questions, indicated by the number of correctly solved items. Thus, the application of the EAQC in a real learning setting and the evaluation of the tool by postgraduate students yielded very promising results. In a next step, the evaluation process should also involve domain experts (e.g. a group of teachers) as well as experts in the field of assessment.

Regarding the tool's usability, SUS scores from both teacher and students were below average, but the teacher was still in a very positive emotional state and open comments from both sides show that they appreciate the tool and its functions. Students indicated that they would benefit from automatic self-assessments and that the course is a worthy educational resource. The results show high task values and high motivational ratings for the different tasks performed during the study. Thus, we can conclude that the EAQC and in general automatic question creators are able to motivate students in their learning activities and should be a fundamental part of SRL environments.

The results from the evaluation of questions generated automatically by EAQC in a broader setting are encouraging. The study, including participants with different cultural background in Latin America, allowed the researchers to test the tool and perception of the assessment in PLEs in order to look for worldwide solutions.

Besides the above mentioned evaluation studies with experts, future work needs to focus on improving the tool's usability, clarity, and performance. Also a focus on the quality of extracted concepts and questions with text in different languages should be considered.

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Predicting Students' Examination Performance with Discovery-embedded Assessment using a Prototype Diagnostic Tool

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Keywords: Diagnostic Tool, Prediction of Examination Achievement, E-Social Networking.

Abstract: Early detection and provision of feedback on learners' performance are essential mechanisms to allow learners to take prompt action to improve their approach to learning. Although students may learn how they perform in mid-term quizzes, the results cannot reflect how they might perform in the final examination. However, quiz results with set answers cannot illustrate the comprehensive skills and knowledge that are expected in university study. This paper reports on the use of a diagnostic tool to analyse the process of students working on a discovery-embedded assessment task in the collaborative learning environment of a microbiology course. The diagnostic tool identified that those learners who performed less well in the assessment tasks also performed less well in the final examination. This tool can provide early detection of those facing learning challenges in comprehensive assessment tasks, so that educators can provide appropriate support.

1 INTRODUCTION

Learners nowadays have had a range of experiences of using digital technology since they were very young (Prensky, 2001). Although many of the devices used have been for entertainment, information retrieval and social networking, they have also been widely used for educational purposes. Technology has been widely used in universities in Hong Kong, and all universities have had institution-wide platforms that enable teaching faculty to communicate and share resources with their students. This allows educators to consider alternative learning experiences so that they can be better engaged and have more opportunities to demonstrate intended learning outcomes for courses. Using technology for assessment, such as online quizzes, is becoming more popular, because these can be used to measure breadth of knowledge and can provide feedback quickly to students (Bierer et al., 2008), and this undoubtedly provides timely feedback to students (Brady, 2005; Nicol, 2007). Although online quizzes may give teaching faculty some indication of student performance, students cannot demonstrate skills in explanation, analysis, evaluation or creating new concepts through quizzes. Teaching faculty therefore design assessment tasks that facilitate the demonstration of higher-order thinking by students, as required in university study. Unlike with online quizzes, the initial challenge for teaching faculty is the lack of resources to provide timely feedback to individual students. Feedback through peer assessment may be incorporated so that students can provide comments and suggestions for individuals or peer groups on their performance (Hodgson and Chan, 2010). However, good preparation and training of students is necessary if reliable peer rating and feedback is to be expected (Xiao and Lucking, 2008).

In considering alternative options for engaging learners and providing feedback for collaborative learning, Web 2.0 tools such as blogs, wikis and forums are often used in university courses. These social media support personalization, collaboration, social networking, social presence and collective wisdom when participants interact with one another (Dabbagha and Kitsantas, 2012). Many different successful cases of social media adoption have been reported in the literature across different disciplines, including business (Barczyk and Duncan, 2012), medical and veterinary (Coe et al., 2012), and science, technology, engineering, and maths (STEM) education (Ahrama et al., 2011). The Committee of Inquiry into the Changing Learner Experience (2009) found that although learners are expected to be participatory and deploy appropriate technical competence in using the applications for academic purposes, some may not have the essential digital literacy or may lack cognitive capabilities such as critical evaluation and therefore adopt a casual approach to evaluating information. Therefore, it is necessary for teaching faculty to make early diagnosis of student learning behaviour.

Different technical solutions have been developed to help teaching faculty to detect students who encounter learning challenges at an early stage so as to provide just-in-time supportive measures. Patterns of individual student activity working through the e-learning platform can be tracked through the system log. Student behaviour is determined by a number of quantitative indicators, such as frequency of log-in, and frequency of various online activities such as postings contributed to online discussions, blogs and wikis. Jong et al. (2007) analysed learners' behaviour, including time spent reading discussion postings, the number of articles submitted and frequency of log-in. In some sophisticated learning diagnostic systems, accuracy of content contributed by learners is evaluated (Hwang et al., forthcoming).

IT solutions can be implemented to analyse learners' behaviour and visualize interactions between individuals and groups. Arnold and Paulus (2010) identified a number of metrics that impact on learning performance: the number of postings in forums, modelling and feedback (i.e. replying to postings), and interactions (i.e., replying to replies, which pertains to various forms of collaboration). One feasible solution is to measure and interpret these metrics to construct a quantitative index to identify students with learning challenges.

In addition, factors such as user-friendliness and timeliness of analysis should be considered when designing a diagnostic tool to predict student performance. Perceived usefulness and perceived ease of use are postulated as critical factors in the Technology Acceptance Model (Davis, 1989), and the latter determines the readiness of users to accept adoption of the system. Timeliness of analysis is equally important, because supportive actions should be provided at an early stage. However, timeliness may be compromised by the analytical accuracy of a diagnostic tool. Lui et al. (2009) assert that timeliness should be emphasized more than accuracy, because decision making on types of support provided can be estimated through the broad prediction of levels of student performance attained.

Considering both the user-friendliness and timeliness of a diagnostic tool, we report the development of a prototype that can be used to diagnose and predict learners' performance. The objectives of the prototype are to (1) evaluate learner contributions in collaborative work, (2) analyse learner engagement in the process during online activities, (3) predict learner performance at the end of the course through visual presentation of diagrams, and (4) alert teaching faculty to take action early for learners who may encounter learning challenges.

2 DEVELOPMENT OF DIAGNOSTIC TOOL: AN ACTION DESIGN RESEARCH APPROACH

Agile methodologies are commonly adopted as the development model for providing 'quick-and-dirty' solutions because of rapid solution delivery, efficient evaluation, instant modification and ease of maintenance (Beck, 1999). Combining action research and design science (Hevner and Chatterjee, 2010) methodologies, Action Design Research (ADR) (Sein et al., 2011) provides the agility and capability for extensive user input from different stakeholders, in which an iterative process takes a holistic view from the perspectives of educators, technologists and stakeholders with dual roles, e.g., teaching staff with strong technology backgrounds. It is essential to have iteration of modifications based on feedback from various stakeholders, given the exploratory nature of the development of the prototype, in order to truly deliver a solution to solve the problems faced by stakeholders.

Analysis, design and development of our diagnostic tool follows the set of guidelines postulated in the ADR approach. Discussion on the four interconnected stages and seven underlying principles, as suggested by Sein et al. (*ibid.*) are presented in the subsections.

2.1 Stage 1: Problem Formulation

The first stage of ADR involves identification of problems by the researchers, often from the practitioners' perspectives. Stage one involves two principles, as described below.

Principle 1: Practice-inspired Research. The research originates from a problem or an issue that has practical value. This usually involves attempts to solve problems happening in real life by developing IT solutions.

In the case of teaching and learning in an institutional context, large class size (often involving more than 100 students) is at the root of many issues that arise (Gleason, 2012). Providing timely and in-depth formative feedback to individual students, especially during the continuous assessment process, becomes difficult for instructors (Cole and Spence, 2012). Moreover, it is extremely difficult to monitor the progress of individual students' learning.

Principle 2: Theory-ingrained Artefact. The researchers then aim to structure the problem. Afterwards, they identify solution possibilities and suggest design guidelines to deliver the solution.

In this case, the problem is structured more accurately: the development of a prototype diagnostic tool to predict students' examination achievements. Most possibly, this prototype makes use of social networking analysis techniques and should be relatively easy for use. Results of the diagnosis should be easy to read and interpret, even for educators without a technical background.

2.2 Stage 2: Building, Intervention and Evaluation

The second stage in ADR involves generating the initial design of the IT artefact, i.e., a holistic view on IT and its application for socio-economic activities that extend beyond the IT solution itself (Orlikowski and Lacono, 2001). This stage involves three principles: guiding participation from different stakeholders, and continuous evaluation and input from these stakeholders.

Principle 3: Reciprocal Shaping. The organizational and technical domains exert inseparable influences on each other. This implies that the organizational settings (e.g., culture and practices) have a significant impact on the technical design of solutions. Similarly, technical solutions have a long-term impact on organizational culture and practices.

In this case, departmental settings and subject-specific settings play an important role in the design of technical solutions. For example, in an academic department with a strong technical background, sophisticated functionalities offered by the system would be dominant. On the other hand, educators' usage experience (UX) would be more favoured than 'geek' functionalities without good UX.

Principle 4: Mutually Influential Roles. The stakeholders in an ADR project should learn from others with different roles. Stakeholders often carry more than one identity, e.g., as a researcher and a practitioner conducting front-line duties.

In the development of the prototype diagnostic tool, stakeholders had different roles: a subject-domain expert in microbiology, an educational practitioner, an e-learning consultant, a technical developer, an educational researcher and an information systems researcher. Some researchers had multiple roles: the subject-domain expert in microbiology was also an educational practitioner and educational researcher, while the e-learning consultant was also an educational practitioner and information systems researcher.

Principle 5: Authentic and Concurrent Evaluation. Instead of evaluating software development at fixed milestones under traditional software engineering models, e.g., waterfall model (Pressman, 2010), evaluation and modification of the prototype should be 'interwoven' at every stage of software development, carefully taking feedback from different stakeholders.

Evaluation of this prototype has been conducted continuously during the development cycle. Typically, the user interface has been optimized to cater for the needs of subject-domain experts in microbiology, who are usually from non-IT backgrounds by presenting controls and results in a graphical format. The metric for evaluating the social networking strength of students was fine-tuned during development to provide more accurate predictions, e.g., the effect of lurking behaviour in the online activities (Weller et al., 2005).

2.3 Stage 3: Reflection and Learning

The third stage of ADR extends the solutions built in the previous stage from a specific problem to a more generalized context. It should be noted that this stage is not linear with the previous stage but happens in parallel with the previous two stages. One important task in this stage is to modify the whole ADR process and future directions continuously according to the experience and lessons learned from the previous two stages.

Principle 6: Guided Emergence. The deliverable combines the continuous effort by all stakeholders and reflects the design that iteratively consolidates the input from concurrent evaluations in the previous stages. The final deliverable, therefore, reflects the organizational use, perspectives and stakeholders' preferences.

During the development stage of this prototype, different stakeholders provided continuous effort in testing and evaluating, similar to the prototyping model adopted in software engineering (Pressman, 2010). Extensive input having been received and reflected in the prototype, this was then ready for trial on additional courses.

2.4 Stage 4: Formalization of Learning

The final stage of ADR formalizes the learning in the whole ADR project and presents knowledge in the form of general solutions to a wider set of problems. Often, the experience and lessons learned are presented to the researchers' and the practitioners' community in the form of IT artefact and research papers.

Principle 7: Generalized Outcomes. Sein et al. (2011) explicitly recommend three deliverables in this stage: (1) generalization of the problem instance, (2) generalization of the solution instance, and (3) derivation of design principles from the design research outcomes (p.44). These are presented in the form of technical solutions (e.g., systems), documents (e.g., best practice and guidelines) and research papers.

In the context of this ADR project on diagnostic tool development, the solutions are presented as (1) a prototype that can be fitted into similar courses that include similar teaching and learning activities; (2) sharing in formal and informal sessions, institutionally and externally; and (3) presentation of research findings in conferences and journals.

The prototype diagnostic tool has been adopted in one microbiology course. The tool should fulfil the objectives as identified in the first stage of the ADR process. It should be able to predict student performance and provide a relatively easy-to-use tool for educators. The next section presents the background of this course.

3 BACKGROUND OF MICROBIOLOGY COURSE

This study was conducted with 77 students in a first-year course on microbiology. Among a variety of assessment tasks in this course, a four-week discovery-embedded assessment task was designed to enhance the engagement of students in their learning of microbiology and was weighted 20 percent of the coursework, compared with 55 percent for the final examination. In the task, students were asked to identify activities or through exploration and observation from their daily lives that were connected with microbiology. They were expected to work in groups to describe the connection between the identified activities or observations with the activity of microbes in comprehensible English and evaluate the positive or negative effects of the activities or observations in relation to the microbes.

To complete the coursework, students had to submit six cases, including three photos and three video clips, each clip lasting no longer than 30 seconds. They had to write some notes (between 30 and 80 words) to describe the activity or observation, stating the relationship between the subject matter in each case with a brief description of the outcome (positive or negative impact) of the activity being observed. In addition to posting all cases to a blog, students had to provide comments to six peer submissions so as to build critical evaluative skills and broaden the scope of their experience.

After the deadline for postings, having made discoveries, observations from their daily lives and critiquing peers on their submissions, the diagnostic tool was used to examine the interactions between students in the blog, and charts were generated to identify active and less active students.

4 ANALYSIS IN AN INTERACTIVE AND VISUAL WAY THROUGH THE PROTOTYPE DIAGNOSTIC TOOL

To fulfil these objectives, the tool analysed interactions between students in the online collaborative activities and presented the analysis in the form of an index and interactive maps.

Figure 1 presents the networking diagram showing the overall connectivity of students in the online activities in the microbiology course. The lines show the pattern of interactions between students. The interconnection between individual students in the online activities are displayed when the node is clicked, showing the nature of collaboration between students. All interactions between students are displayed as light grey lines in the system. Activities performed by an individual student would be displayed when the mouse cursor pointed to his/her name. A red line connecting two students implies that the other student made a comment to the student being analysed (inbound). A green line denotes that the student being analysed made a comment to the other student (outbound). When two students had both inbound and outbound activities, the line is displayed in yellow (bi-directional). Student identities cannot be disclosed due to the privacy legislation in Hong Kong. Therefore, parts of student names have been blurred in the figures shown here.

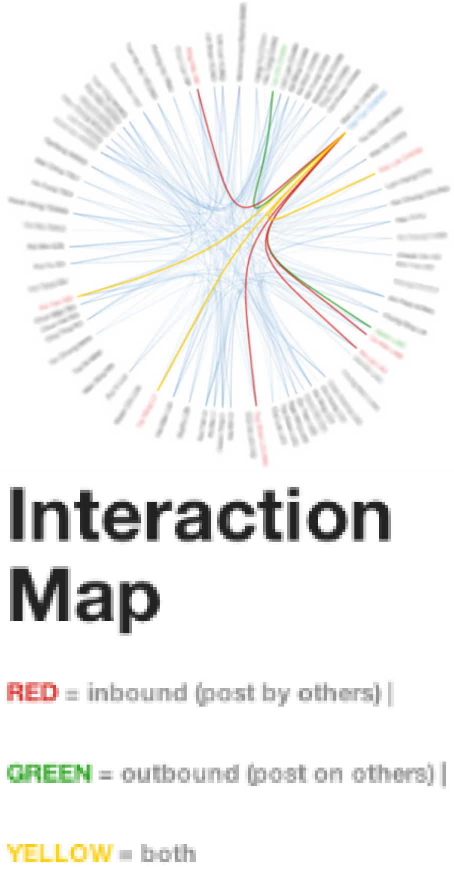

Figure 1: Connectivity of students on the microbiology course.

Apart from showing the nature of connectivity, the system can show the 'intensity' (i.e., number of postings) of student participation. When an individual node is clicked, the social network of the student will be displayed. Figure 2 shows the initial interaction network generated by the tool. The size of a node indicates the intensity of student participation in the online activities. The small nodes at the middle indicate 'disconnected' students. Different colours are used to indicate students with similar intensity of participation.

Figure 3 shows a display of the direction and nature of posts. The same colour notations (red, green and yellow) are used to represent inbound, outbound and bi-directional comments made in Figure 1. Similarly, the size of each node indicates the intensity of student participation in the online activities.

Figure 2: Intensity of student participation.

Dawson (2010) acknowledges that monitoring and visualizing the student online community would be an effective way to identify "at risk" students. Early and effective detection of these "at risk" students allows educators to prepare better remedial actions before it is too late for the final major assessment task. The "disconnected" students (i.e., students who seldom take part in the online collaborative activities) may represent those who are less engaged in a course, and will probably be those who require more attention from educators.

5 DIAGNOSTIC RESULT OF THE MICROBIOLOGY COURSE

The metric adopted to evaluate the accuracy of the diagnostic tool is the percentage of 'at risk' students identified by the tool. These students we describe as less engaged for the paper. Theoretically, the tool

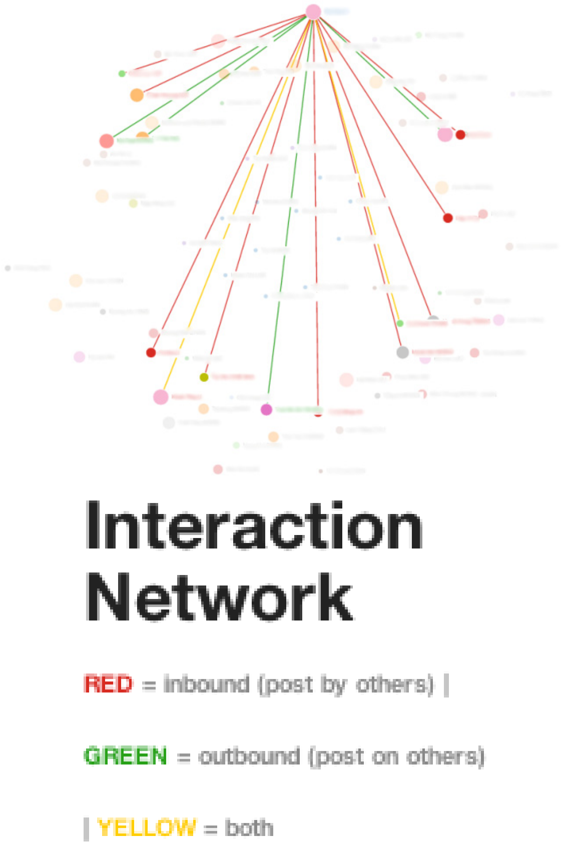

Figure 3: Direction and nature of posts contributed by individual students.

should be able to predict those students who achieve below the median score in assessment tasks if no action is taken. The result of the final open-book examination was used as the benchmark, as the coursework component was related to the online activities.

Although 77 students enrolled, two students dropped out, and 75 enrolments were recorded at the final examination. Examination results for the whole class were divided into four quartiles in ascending order of scores: Q1 (lowest 25%), Q2 (next 25% below the median), Q3 (next 25% above the median) and Q4 (top 25%). Fourteen out of the 37 (37.8%) less engaged students identified by the tool performed at or below the 50th percentile in the final examination.

The purpose of the prototype diagnostic tool was to provide early diagnosis to educators so that timely action could be taken to address students' learning difficulties. However it was not designed to provide a very accurate prediction of student performance in the final examination. Like many other forecasts, false alerts for some outlier cases cannot be avoided, and four students were identified in Q3 and Q4 in this case. Rapid prediction of student performance who fell into Q1 and Q2 would be of significant value to educators, because use of the tool has the potential to reduce significantly the effort needed to identify the less engaged students.

Table 1: 'At risk' students as identified by the prototype diagnostic tool in different quartiles.

Quartile	No. of students	'Less engaged' students identified
Q1	18	7
Q2	19	7
Q3	19	3
Q4	19	1

Interpreting the number of posts in the online collaborative activities may provide a quantitative indicator of student engagement and participation. However, it does not provide comprehensive information, because the quality of online postings is not taken into account. For example, some postings on interesting topics may attract more responses for discussion. Therefore, it is necessary to evaluate students' contributions in a more comprehensive way, including evaluating the original posts by students, replies by others, and subsequent responses between students.

6 DISCUSSION

The purpose of designing this system was to provide an efficient way of identifying students with learning needs under tight time and human resource constraints, and to provide them with timely advice and help. This tool can be used primarily for diagnosis and should not be used solely to predict examination performance.

Application of this diagnostic tool extended beyond predicting the less engaged students to tracing interactions of these students in the associated social network in the study. It was observed that the less engaged students had few interactions and fewer students to interact with. This implies that the social network of those students was relatively closed. Educators can make use of the interaction network map generated by the diagnostic tool to trace the social network of the less engaged students, as students in the same social network may also be potentially 'at risk'. They can proactively make use of this tool to provide formative and timely feedback to those students, and to help them to overcome difficulties encountered in learning.

7 LIMITATIONS AND NEXT STEPS

We acknowledge that there are a few limitations on the existing version of the diagnostic tool. This includes no screening for quality of content in the postings, the tool providing only visual analysis of the nature and intensity of postings between students. The tool counts all postings; however, the content of some postings may not have significant value, e.g., postings such as 'thank you' or 'I agree' with no further explanation or justification. Second, it does not analyse when postings are submitted. It was observed that many postings were submitted shortly before the cut-off time for the online activities. Active learners may consider various learning opportunities and show engagement across the study period, and they would contribute postings during the whole period of the online task. Subsequently, students had multiple moments of engagement that would allow them to think, reflect on and review the discussion.

8 CONCLUSIONS

Teaching large classes is common in universities, and educators are expected to provide timely feedback. Automated computer-generated feedback may be perceived as a plausible option. However, educators may not be able to identify the less engaged students before the marking of final term papers. Emerging from the educational practitioner's needs, a diagnostic tool for predicting student academic engagement was developed iteratively using the ADR approach. The pilot run of the tool showed the connections between students in the online activities. It successfully predicted 37.8% of the less engaged students who performed below the median in the final examination. However, the use of the diagnostic tool should provide timely assistance to those students, and to further identify other potential less engaged students through social network analysis. Within the social network of the course, there was a tendency for students producing similar performances to collaborate and connect with each other. This may be explained by the traditional English proverb, '*birds of a feather flock together*', which is also exhibited in users' blogging activities. Li and Chignell (2010) postulate that bloggers have a tendency to interact with other bloggers (e.g., replying to and continuing discussions) who share similar interests. By engaging active learners, educators can consider involving them to provide early assistance or mentoring to the less engaged students.

The next steps towards improving this diagnostic tool would include fine-tuning the metric for analysis and automatic importation of collaborative content from the learning management system. It is essential to keep track of posting time to the system, so that we can evaluate the effects of last-minute postings. Modification of the existing evaluation metrics would be needed. To further automate the process of importing collaborative data, an application programming interface (API) may be developed to reduce manual data importing before analysis.

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CTSiM: A Computational Thinking Environment for Learning Science through Simulation and Modeling

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Keywords: Computational Thinking, Agent-based Modeling, Simulations, Visual Programming, Learning-by-Design, Scaffolding, Science Education.

Abstract: Computational thinking (CT) draws on fundamental computer science concepts to formulate and solve problems, design systems, and understand human behavior. CT practices (*e.g.*, problem representation, abstraction, decomposition, simulation, verification, and prediction) are also central to the development of expertise in a variety of STEM disciplines. Exploiting this synergy between CT and STEM disciplines, we have developed CTSiM, a cross-domain, scaffolded, visual-programming and agent-based learning environment for middle school science. We present and justify the CTSiM architecture and its implementation. To identify challenges and scaffolding needs in learning with CTSiM, we present a case study describing the challenges that a high- and a low-achieving student faced while working on kinematics and ecology units using CTSiM. Decreases in the number of challenges for both students over sequences of related activities illustrate the combined effectiveness of our approach. Further, the specific challenges and scaffolds identified suggest the design of an adaptive scaffolding framework to help students develop a synergistic understanding of CT and science concepts.

1 INTRODUCTION

Science education in K-12 classrooms has been a topic of growing importance. The National Research Council framework for K-12 science education (NRC, 2011) includes several core science and engineering practices: asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, and constructing explanations and designing solutions. Several of these epistemic and representational practices central to the development of expertise in STEM disciplines are also primary components of Computational Thinking (CT). CT involves formulating and solving problems, designing systems, and understanding human behavior by drawing on the fundamental concepts of computer science (Wing, 2010). Specifically, CT promotes abstraction, problem representation, decomposition, simulation, and verification practices. Thus it is not surprising that CT is included as a key feature in NRC's K-12 science education framework. In fact, several researchers suggest that programming and computational modeling can serve as effective vehicles for learning challenging STEM concepts (Guzdial, 1995; Sherin, 2001; Hambrusch et al., 2009).

In spite of the observed synergies between CT and STEM education, empirical studies have shown that balancing and exploiting the trade-off between the domain-generality of CT and the domain-specificity of scientific representations, presents an important educational design challenge (Sengupta et al., 2012a). Thus, Sengupta et al. (2012b, 2013) and Basu et al. (2012) proposed CTSiM (Computational Thinking in Simulation and Modeling) for K-12 science learning using a computational thinking approach. CTSiM provides an agent-based, visual programming interface for constructing executable computational models and allows students to execute their models as simulations and compare their models' behaviors with that of an expert model.

In this paper, building upon our previous work, we present key design principles and their translation to details of the CTSiM architecture (Sengupta et al., 2013; Basu et al., 2012). In an initial study with 6th-grade students in a middle Tennessee public school, students showed high pre-post learning gains and a good understanding of the basic science concepts. However, students also faced a number of challenges while working with CTSiM. This paper presents a case study that discusses the challenges that a high and a low achieving student faced while working on a physics and a biology unit using CTSiM. We compare and contrast the challenges faced by the two students, and discuss how the challenges evolved over time. The set of challenges, and the scaffolding provided to help overcome them, suggest the design of an adaptive scaffolding framework to help students develop a synergistic understanding of CT and science concepts.

2 CTSiM DESIGN PRINCIPLES AND ARCHITECTURE

This section discusses a set of key principles that guide the design and implementation of CTSiM (Sengupta et al., 2012b, 2013; Basu, et al., 2012). The design principles and the corresponding implementation decisions are summarized in Table1.

2.1 CTSiM Design Principles

Wing's notion of CT (Wing, 2010) emphasizes abstractions and the automation of abstractions. In computer science, abstractions represent generalizations and parametric forms of code segment instances. They capture essential properties common to a set of objects while hiding irrelevant distinctions among them. According to Wing, the "nuts and bolts" in CT involve defining multiple layers of abstraction, understanding the relationships between the layers, and deciding what details need to be highlighted (and complementarily, what details can be ignored) in each layer. This led to our first 2 design principles (DP) -

DP1: *Engage students in defining multiple layers of computational abstractions to represent different aspects of the domain*, and

DP2: *Help students understand relations between the abstraction layers by mechanizing the relationships*.

Another important characteristic of CT is its focus on conceptualization and developing ideas on how to solve a problem rather than producing software and hardware artifacts that represent the solution to a problem. This forms the basis for

DP3: *Help students conceptualize phenomena rather than program them using rigid syntax and semantics*.

When CT mechanisms are anchored in real-world problem contexts, programming and computational modeling become easier to learn (Hambrusch et al., 2009). Also, reorganizing scientific and mathematical concepts around computational mechanisms lowers the learning threshold, especially in domains like physics and biology (Redish and Wilson, 1993). Learning environments that adopt this approach need to make the CT principles explicit and easy to apply, without limiting the range of phenomena that can be modeled (high-ceiling) and the types of artifacts that can be studied (wide-walls), to make them widely applicable in K-12 classrooms (Sengupta et al., 2012b). This leads to two additional principles:

DP4: *Make the learning environment encompass wide-walls and high-ceilings to provide a common set of principles for studying multiple STEM disciplines*, and

DP5: *Make the CT principles in a domain and the computational commonalities across domains explicit and easy to use*.

The rest of our design principles draw on the modeling literature. Modeling – the collective action of developing, testing and refining models - has been described as the core epistemic and representational practice in the sciences (Lehrer and Schauble, 2006). Using this we establish:

DP6: *Adopt a modeling paradigm which is intuitive and easily understandable by K-12 students*.

We choose an agent-based modeling paradigm since it is believed to productively leverage students' pre-instructional intuitions, and it helps in learning of complex systems and emergent phenomena in science domains (Wilensky and Reisman, 2006). Logo (Papert, 1980), a well-known agent-based programming language used to support children' learning through the creation of artifacts, facilitates simultaneous learning of concepts about the domain phenomena and computational concepts, such as procedure abstraction, iteration, and recursion.

Also, to help students seamlessly progress through cycles of algorithm construction, visualization, analysis, reflection and refinement with timely feedback, we have

DP7: *Incorporate multiple "liveness" factors as support for programming and learning by design*.

After model construction, learning is believed to occur by comparing the model behavior against that of a correct model or real world data. Thus, we have

DP8: *Enable verification and validation of computational models.*

Finally, to help students model real-world phenomena and to apply their skills learnt through modeling to real world problems, we have

DP9: *Draw on engineering thinking by building sys-*

tems that model and interact with the real world.

2.2 Implementing Design Principles: The CTSiM Architecture

We base the conceptual framework for our pedagogical approach on a typical learning-by-design sequence. Figure 1 depicts the CTSiM activity sequence which integrates our conceptual framework with the agent-based modeling paradigm.

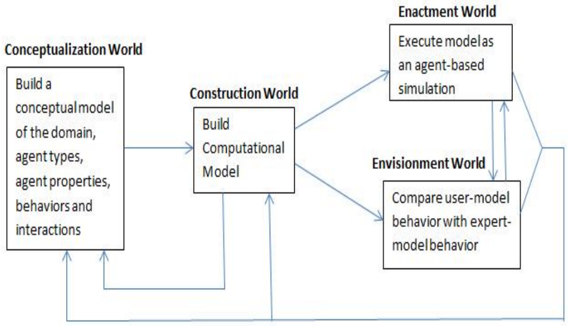


Figure 1: Sequence of activities performed by a student in the CTSiM learning environment.

Initially, students conceptualize the science phenomena by structuring it in terms of the types of agents involved, their properties, behaviors, and interactions in what we call the 'Conceptualization World'. They then construct computational models describing the behavior of each agent type in the Construction or C-World. Engaging students in modeling at two different levels of abstraction helps implement DP1. Students can view another layer of abstraction by executing their models as agent-based NetLogo simulations (Wilensky, 1999) in the Enactment or E-World. Following DP2, the agent types and properties specified in the conceptual model determine what students can model in the C-World. Similarly, the computational models constructed determine what students see in the E-World. Students can also verify the correctness of their models by comparing the simulations generated by their models against 'expert' simulations in the Envisionment or V-World (this implements DP8).

The next design decision involved choosing a mode of programming for the C-World to enable students to represent phenomena computationally without having to learn the syntax and semantics of a programming language (see DP3).

We focus on visual programming (VP) as the mode of programming to make it easier for middle school students to translate their intuitive knowledge of scientific phenomena (whether correct or incorrect) into executable models (Sengupta et al., 2012b, 2013). In such environments, students typically construct programs using graphical objects in a drag-and-drop interface (Kelleher and Pausch, 2005). This significantly reduces students' challenges in learning the language syntax (compared to text-based programming), and thus makes programming more accessible to novices. Unlike some agent-based VP environments like AgentSheets (Repening, 1993), StarLogo TNG (Klopfer et al., 2005), Scratch (Maloney et al., 2004), and Alice (Conway, 1997), which have often been employed with game design as the core programming activity, our goal is to focus on using VP to support scientific modeling and simulation.

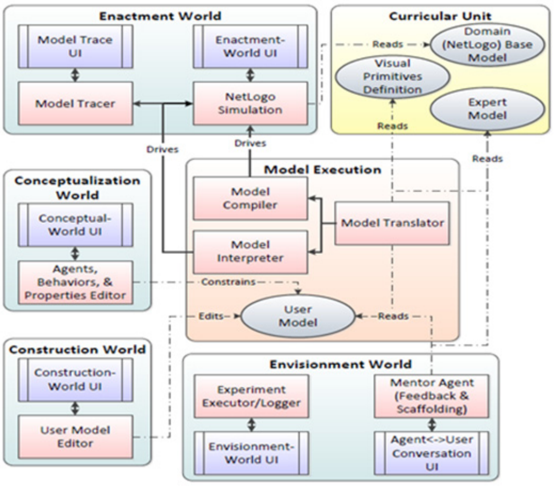


Figure 2: The CTSiM architecture.

The CTSiM C-World consists of a library of visual primitives from which students can choose primitives and spatially arrange them to generate their computational models. These primitives include both domain-specific and domain-general primitives (Sengupta et al., 2013). The set of available visual primitives may vary with the domain or curricular unit being modeled. Different curricular units of varying complexities can be defined by specifying (i) a set of available visual primitives, (ii) an expert computational model using these primitives, and (iii) a NetLogo-based domain model (implements DP4). Some of these visual primitives are specific to the domain being modeled, while others related to CT principles are domain-general and can be reused across domains (in accordance with DP5). The visual primitives are internally translated to an intermediate language (a limited set of computational primitives), which is then compiled into NetLogo code to generate a simulation corresponding to the

Table 1: Design principles and corresponding implementation decisions.

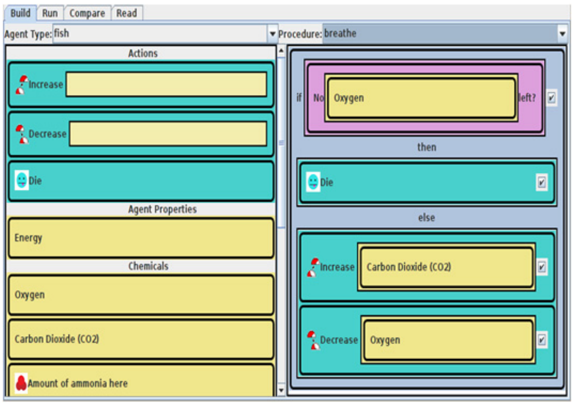
Design Principles (DP)	**Implementation Decisions**
DP1: Engage students in defining multiple layers of computational abstractions to represent different aspects of the domain	Students construct conceptual models (structural and behavioural layer) and computational models(functional layer), and can also execute their models as simulations
DP2: Help students understand relations between the abstraction layers by mechanizing the relationships	Conceptual model determines available primitives in the C-World, Computational model determines simulation
DP3: Help students conceptualize phenomena rather than program them using rigid syntax and semantics	Employ a drag-and-drop visual programming interface
DP4: Make the learning environment encompass wide-walls and high-ceilings to provide a common set of principles for studying multiple STEM disciplines	Ability to define any domain in terms of a base model in NetLogo, a list of available primitives, and an expert computational model using those primitives
DP5: Make the CT principles in a domain and the computational commonalities across domains explicit and easy to use	For each domain, define some visual primitives which are domain-specific and others which are domain-general; re-use the domain-general primitives across multiple domains
DP6: Adopt a modeling paradigm which is intuitive and easily understandable by K-12 students	Employ an agent-based modeling/programming paradigm
DP7: Incorporate multiple "liveness" factors as support for programming and learning by design	Include functionalities for code-highlighting, and commenting out code
DP8: Enable verification and validation of computational models	Implement the Enactment and Envisionment worlds
DP9: Draw on engineering thinking by building systems that model and interact with the real world	Make students analyze real world data in the conceptualization phase; Then, apply concepts learnt to real world problems

user model. Figure 2 presents the architecture for the CTSiM learning environment. In Section 3, we describe the details of the different components of the architecture which we have already implemented. Other components like the Conceptualization World will be implemented in future versions of CTSiM.

3 CTSiM IMPLEMENTATION

3.1 The Construction or C-World

The C-World allows students to build computational models using an agent-based, visual programming interface (see Figure 3). The students choose the type of agent and procedure they are modeling at the top of the screen. A list of visual primitives, along with corresponding icons, is provided on the left pane. These primitives are of three types: agent actions (e.g., moving, eating, reproducing), sensing conditions (e.g., vision, color, touch, toxicity), and controls for regulating the flow of execution in the computational model (e.g., conditionals, loops). Students drag and drop these available primitives onto the right pane, arranging and parameterizing them spatially to construct their models.



Agent Type: fish

Procedure: breathe

Figure 3: Construction world with a 'breathe' procedure for 'fish' agents in a fish-tank unit.

3.2 The Enactment or E-World

The E-World allows students to define a scenario (by assigning initial values to a set of parameters) and visualize the multi-agent-based simulation driven by their computational model, as seen in Figure 4. CTSiM, written in Java, includes an embedded NetLogo instance to implement the simulation. Students' models are represented in the system as code graphs of parameterized computational primitives. These code graphs remain hidden from the end-user (the learner), and are translated into NetLogo commands to generate the simulations. NetLogo visualizations and plotting functionalities provide the students with a dynamic, real-time display of how their agents operate in the microworld, thus making explicit the emergence of aggregate system behaviours.

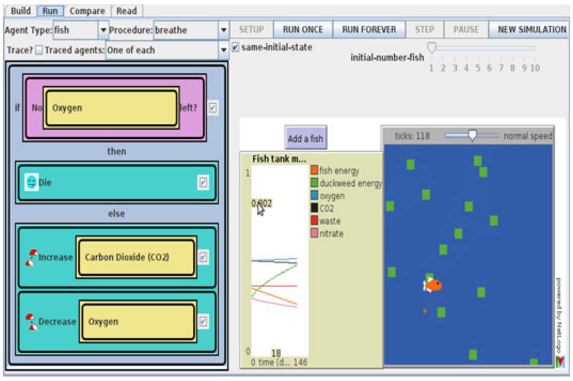


Figure 4: The Enactment world for a fish-tank unit.

Furthermore, CTSiM supports model tracing, meaning that the system can highlight each primitive in the C-World as it is being executed in the E-World (implements DP7). In order to achieve normal speed of execution, the 'model trace runner' is treated as an alternate model execution path available in the E-World (see Figure 2) where each visual primitive is translated separately via the Model Interpreter, instead of the entire user model being translated to NetLogo code. Such supports for making algorithms "live", helps students better understand the correspondence between their models and simulations, as well as identify and correct model errors. CTSiM also supports execution of subsets of the code in the C-World through the standard programming practice of "commenting out" parts of the computational model, allowing students to test their models in parts. These functionalities can be leveraged to provide important scaffolding that supports model refinement and debugging activities.

3.3 The Envisionment or V-World

The V-World allows students to systematically design experiments to test their constructed models and compare their model behaviours against that of an "expert" model, as seen in Figure 5. Although the expert model itself is hidden, students observe its behaviour, comparing it with their own models, through side-by-side plots and microworld visualizations. Additional scaffolding will help students decide what components of their models they need to investigate, develop further, or check for errors, and propose corrective actions.

3.4 The Computational Language

At the high level, our computational language comprises the visual primitives available to the end user in the C-World, as described in Section 3.1. Each visual primitive, in turn, is defined in terms of one or more underlying computational primitives with appropriate constraints and parameters, to form what we call 'code graphs'. The computational primitives provide a domain-independent set of computational constructs in a limited set of categories. Since the expert model in CTSiM is described using the same set of visual primitives available to the students, both student-built and pre-defined expert models can be executed, analyzed, and compared using the same computational language. Finally, this intermediate language of computational primitives is translated to NetLogo code to produce the E and V world simulations.

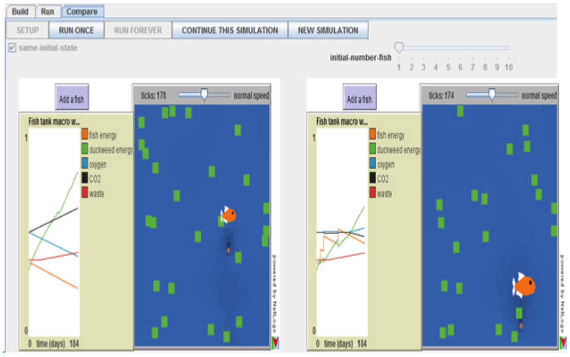


Figure 5: The Envisionment world for a fish-tank unit.

For example, Figure 4 shows a visual primitive 'Increase' with the argument (another visual primitive) 'Carbon Dioxide (CO_2)'. The CO_2 block is simply defined by a single computational primitive corresponding to the environment (global) variable for CO_2. However, because of the goals and target grade-level of this unit, the student does not specify any other (*e.g.*, quantitative) arguments for the 'Increase' block. Instead, the appropriate quantities for the simulation are part of the computational definition of the 'Increase' visual primitive, which is actually a series of checks corresponding to the possible visual primitives that could be provided as arguments to 'Increase'. For each possible visual primitive (e.g., the CO_2 block used in the example), the computational definition specifies the quantity by which the primitive's value should be increased. Since the computational primitives are constant for all units, the same model translator can analyse or execute students' models with different unit-specific visual primitives.

3.5 The Model Executor

In CTSiM, the model executor (see Figure 2), translates a (student-built or expert) model into corresponding NetLogo code, which is then combined with the domain base model. The base model provides NetLogo code for visualization and other housekeeping aspects of the simulation that are not directly relevant to the learning goals of the unit. The combined model forms a complete, executable NetLogo simulation, to run in the E or V Worlds.

As seen in Section 3.2, the executor provides an alternate path through the 'Model Tracer'. Using the Model Tracer, instead of translating the entire student-generated model into NetLogo code, each visual primitive is translated separately, and highlighted in the C-World as it is executed.

3.6 Defining New Curricular Units

Defining a new unit using the CTSiM architecture is fairly straightforward and involves defining the following components: (i) an xml file defining visual primitives for the unit (in terms of computational primitives), (ii) an xml file describing how the visual primitive blocks are to be depicted graphically in the C-World, including name, positions for arguments, color, etc., (iii) an xml file describing the expert computational model using the visual primitives defined for the unit, and (iv) a domain base model which is responsible for the NetLogo visualization and other housekeeping aspects of the simulation.

4 METHOD

We describe a study conducted with 6th-grade middle Tennessee students who worked on two units in Kinematics and Ecology using CTSiM.

4.1 CTSiM Curricular Units

Kinematics Unit

Kinematics unit activities were divided into three phases (Basu et al., 2012; Sengupta et al., 2013):

Phase 1: Turtle Graphics for Constant Speed and Acceleration - Students generated algorithms to draw simple shapes (squares, triangles and circles) to familiarize them with programming primitives such as "forward", "right turn", "left turn", "pen down", "pen up" and "repeat". Students then modified their algorithms to generate spirals where each line segment was longer (or shorter) than the previous one. This exercise introduced students to the "speed-up" and "slow-down" commands, and allowed them to explore the relationship between speed, acceleration, and distance.

Phase II: Conceptualizing and Re-representing a Speed-time Graph - Students generated shapes where the length of segments was proportional to the speed in a given speed-time graph. For example, the initial spurt of acceleration in the graph was represented by a small growing spiral, the gradual deceleration by a large shrinking spiral, and constant speed by a shape like a triangle, square, and so on. The focus was on developing mathematical measures from meaningful estimation and mechanistic interpretations of the graph, and thereby gaining a deeper understanding of concepts like speed and acceleration.

Phase III: Modeling Motion of an Agent to match Expert behavior - Students modeled a roller coaster's behavior as it moved on different segments of a track: up (pulled by a motor), down, flat , and then up again. Students were first shown a simulation corresponding to an 'expert' roller coaster model in the V world. Then, they conceptualized and built their own agent model to match the observed expert roller coaster behavior for all of the segments.

Ecology Unit

In the Ecology unit students modeled a closed fish tank system in two steps: (1) a macro-level semi-stable model for fish and duckweed; and (2) a micro-level model of the waste cycle with bacteria. The macro model required modeling the food chain, the respiration and reproductive processes of the fish and duckweed, and the macro-level elements of the waste cycle. The non-sustainability of the macro-model (the fish and the duckweed gradually died off), encouraged students to reflect on what might be missing from the model, prompting the transition to the micro model. They identified the continuously increasing fish waste as the culprit, and this triggered the introduction of bacteria in the system.

At the micro level, students modeled the waste cycle with bacteria converting the toxic ammonia in the fish waste to nitrites, and then nitrates, which sustained the duckweed. The graphs generated from the expert simulation helped students understand the producer-consumer relations between the bacteria and the chemicals.

4.2 Setting and Study Design

15 6th graders worked on CTSiM outside the classroom with one-on-one verbal guidance from one of 5 members of our research team (Scaffolded or S-Group), while the remaining 9 students worked in the classroom (Classroom or C-Group) with some instruction from the researchers and the classroom

teacher. The C group also received individual help from the researchers if they raised their hand. The students were assigned to the groups by their classroom teacher.

All students worked on the three phases of the kinematics unit before the ecology macro and micro units. After completing the ecology micro unit, the S group received an additional scaffold: they discussed the combined micro-macro model with their assigned researcher and how the two models were causally linked to support sustainability.

Students worked on the two science units in hour-long sessions for three days each. The units provided a natural sequencing in which students first learned to model and reason with a single agent in kinematics and then went on to model multiple agents and their interactions in ecology.

4.3 Assessments

The Kinematics pre/post-test assessed whether agent-based modeling improved students' abilities to generate mathematical representations of motion and reason causally about them. Specifically, the test required interpretation of speed versus time graphs and generating diagrammatic representations to explain motion in a constant acceleration field. For the Ecology unit, the pre/post-test focused on students' understanding of the role of species in the ecosystem, interdependence among the species, the waste and respiration cycles, and how a change in one species affected the others.

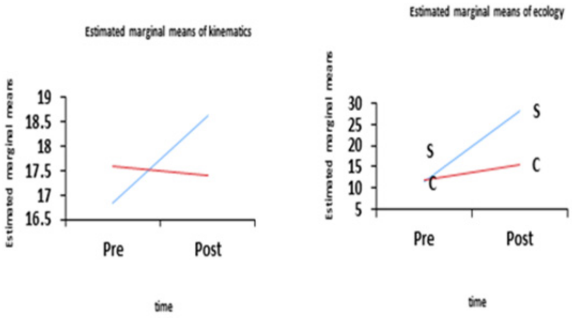


Figure 6: Comparison of gains between groups using TCAP scores as a covariate.

5 RESULTS

5.1 Learning Gains with CTSiM

The intervention produced statistically significant gains for the Ecology unit, but not for the Kinematics unit (Basu et al., 2012), as seen in Table 2. However, as expected, for both units, the S group, which received direct one-on-one scaffolding, showed higher learning gains than the C group.

The lack of statistical significance in the kinematics unit may be attributed to a ceiling effect (students in both groups had high pre-test scores). In the ecology unit, significant gains were observed for both groups, which can be attributed to an increased awareness of the entities in the fish tank and their relations with other species. However, the supplementary causal-reasoning activity helped the S-group students gain a better understanding of the interdependence among the species, compared to the C-Group, which received minimal scaffolding and none targeted towards causal reasoning.

To account for prior knowledge differences between groups, we computed a repeated measures ANCOVA with TCAP (Tennessee Comprehensive Assessment Program) science scores as a covariate to study the interaction between time and condition. There was still a significant effect of condition on learning gains in ecology ($F(1,21)=37.012$, $p<0.001$), and a similar trend was seen in kinematics ($F(1,21)=4.101, p<0.06$) (Figure 6 shows adjusted gains).

5.2 Analyzing Students' Experiences

Along with demonstrating the effectiveness of our overall approach, we also studied students' interactions with CTSiM in more depth – the challenges they faced and the scaffolds they required – in order to identify areas for improvement and embedded, adaptive scaffolding in the system. To investigate students' conceptual development, we adopted an explanatory case study approach (Gomm et al., 2000). In this analysis, we consider two representative cases from the S-group: Jim and Sara (names changed to maintain student anonymity).

Based on pre-test responses and TCAP scores, we chose Jim and Sara because they were representative of the high- and low-performing students, respectively. We contrast their experiences with the CTSiM units in terms of the number and types of challenges they encountered. Activities 1-7 in the analysis refer to: A1 - Kinematics constant speed shape drawing, A2 - Variable speed shape drawing, A3 - Re-representing a speed-time graph, A4 - Roller-coaster activity, A5 - Ecology fish-tank macro-unit, A6 - Fish-tank micro-unit, A7 - Combined fish-tank macro- and micro-unit.

Number of Challenges

For both Jim and Sara and for both curricular units,

Table 2: Paired t-test results for Kinematics and Ecology pre and post test scores.

	Kinematics				**Ecology**			
	PRE (S.D.) (max=24)	**POST (S.D.) (max=24)**	**t-value**	**P-value (2-tailed)**	**PRE (S.D.) (max=35.5)**	**POST (S.D.) (max=35.5)**	**t-value**	**P-value (2-tailed)**
S-Group (n=15)	18.07 (2.05)	19.6 (2.29)	.699	0.017	13.03(5.35)	29.4(4.99)	8.664	<0.001
C-Group (n=9)	15.56 (4.1)	15.78 (4.41)	0.512	0.622	9.61(3.14)	13.78(4.37)	3.402	<0.01

Table 3: Types of programming challenges and scaffolds.

Programming Challenges	**Description of challenges**	**Scaffolds**
Syntax and Semantics of Primitives	Difficulty understanding the usage, functionality, and enactment of certain visual primitives	Step through the code and explain the functionality of primitives by showing their behaviour in the E-World; Explain correct syntax for primitives
Procedurality	Difficulty in specifying a task in terms of a finite set of steps, and ordering the steps correctly to reach a desired goal	Prompt the student to describe the phenomena and break it into subparts and the steps within each subpart.
Modularity	Difficulty in separating the functionality of the agents into independent modules such that each module executes only one aspect of the desired functionality	Prompt student to think about which procedure they are currently modeling and whether their code pertains to only that procedure
Code Reuse	Difficulty in identifying already written similar code to reuse, what parts of similar code to modify	Prompt for analogous reasoning; Making students think about what similar procedures they have already written
Conditionals, Loops, Nesting, Variables	Difficultly in understanding role of variables, repeat-structures, conditionals and how to nest procedures within other conditional statements	Explain concept of a variable using examples; Explain syntax and semantics of loops and nested conditions using code snippets and their enactment
Debugging	Difficulty in methodically finding and reducing the number of 'bugs', or unexpected outcomes, in the program	Prompts to think about which part of the code might be causing the bug; help break down the task by trying to get one code segment to work before moving onto another.

the number of challenges faced generally decreased with time for similar units, but went back up when new computational constructs or modeling complexities were introduced through new activities (see Figure 7a). In case of Jim, the number of challenges he faced in the Kinematics unit decreased from A1 to A3, but rose again when he worked on A4. This was expected as the roller coaster activity introduced many new computational constructs like variables, conditionals, and nesting of blocks. Also, A4 required students to generate abstractions of a real-world phenomenon – a more complex modeling task compared to shape-drawing. Similarly, in the ecology unit students had the more complex task of modeling multiple agent types and procedures defining the behaviour of each agent type.

Expectedly, Jim's number of challenges is initially high in the macro model and decreases as he progresses through the micro and combined models. In the case of Sara, the number of challenges she faced in the A1-A3, did not decrease like they did for Jim. The challenges, though scaffolded, persisted through A1-A3. A potential explanation for this difference is

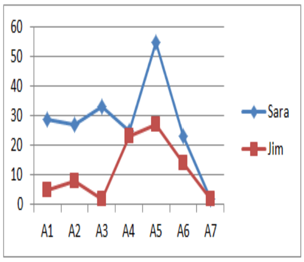


Figure 7a: Number of challenges over time.

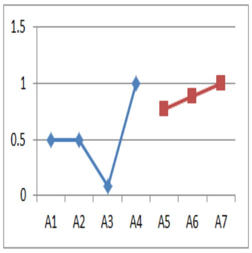


Figure 7b: Number (normalized) of similar challenges over time.

Table 4: Types of modeling challenges and scaffolds.

Modeling Challenges	Description of challenges	Scaffolds
Identifying Entities and Interactions	Difficulty in identifying agents to model and their properties and how they interact with each other	Point out the appropriate aspects of the phenomena that need to be modeled and prompt student to think about the interactions
Choosing Correct Initial Conditions	Difficulty in identifying and setting appropriate initial conditions to produce measurable and observable outcomes	Prompt student to think about the preconditions necessary for certain functions, Encourage students to vary initial conditions
Systematicity	Difficulty in methodical exploration; guessing; not using sim to inform changes	Encourage student to think about their goal, the starting point, and their plan of action
Specifying Model Parameters	Difficulty in determining parameters for the visual primitive blocks in the C-World	Prompt student to make a parameter change for more visible output; Encourage testing outcomes by varying parameter values
Model Validation	Difficulty in verifying and validating model by comparing and identifying differences with an expert model	Ask student to slow down the simulation to make agent actions more visible; Point out the differences between the user and export model

Jim's higher initial knowledge of mathematics and physics, confirmed by the differences in their TCAP and pre-test scores. However, by the time Sara started working on A4, the number of challenges she faced was about the same as Jim's, indicating that the CTSiM intervention helped both students in spite of their initial differences. Moreover, the low performing students seemed to improve their understanding of domain and computational constructs, and, the type of challenges encountered by all students gradually became similar, as shown in Figure 7b. The only exception is A3 owing to a floor effect caused by Jim's negligible number of challenges in the activity.

Types of Challenges Faced by Jim and Sara

In order to better understand Jim and Sara's experiences with CTSiM, we further classified the challenges and analyzed the scaffolds provided to overcome them. Most challenges were related to modeling and programming, while some were based on the domain and agent-based-reasoning. A few common modeling challenges involved guessing turn angles for shape drawing instead of systematically using a compass and the E-World to help discover them, failing to recognize the relationships between ramp steepness and gravity in changing the speed of the roller coaster, and choosing forward lengths too small to produce observable outcomes. Some common programming challenges included problems with nesting conditions with and without a motor for the roller coaster, understanding that 'swim' and 'eat functionalities had to be separated into different procedures for a fish, realizing that a fish had to be hungry as well as have food in order to be able to eat, etc. Tables 3 and 4 classify the programming and modeling challenges faced, and the scaffolds provided by the experimenters to help the students overcome these challenges.

Figures 8 and 9 depict how the different types of programming and modeling challenges vary over time for both Jim and Sara. We see that the trends are very similar to those seen in Figure 7a for the total number of challenges over time, especially for the programming challenges.

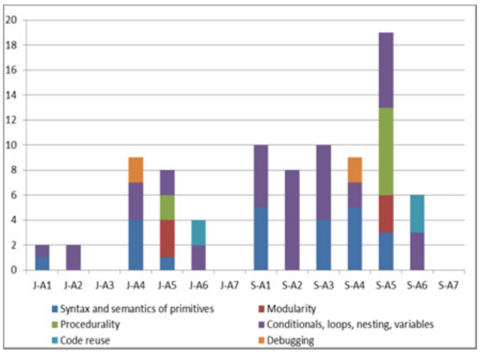


Figure 8: Comparison of Programming Challenges per activity for Jim (J) and Sara (S).

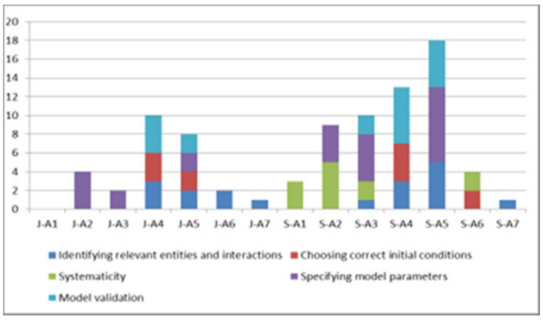


Figure 9: Comparison of Modeling Challenges per activity for Jim (J) and Sara (S).

6 CONCLUSIONS

In this paper, we have provided an overview of the core design principles and architecture of CTSiM – a learning environment which seamlessly integrates domain-general CT concepts with domain-specific representational practices of a variety of STEM disciplines. Using a kinematics and and an ecology unit, we show how CTSiM is effective in producing learning gains for both science topics. We also explained and classified a variety of challenges (and corresponding scaffolds) faced by a high- and a low-performing student while they worked with CTSiM.

Our results indicate that the challenges faced by these students generally decreased with time for sequences of related units, but, as expected, again increased when new computational constructs or modeling complexities were introduced. The decrease in the number of challenges illustrates the combined effectiveness of our architecture, curricular unit design, and scaffolds. Further, the specific challenges and scaffolds identified lay the groundwork for integrating adaptive scaffolding in CTSiM to help students develop a synergistic understanding of CT and science concepts.

ACKNOWLEDGEMENTS

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SHORT PAPERS

Teaching and Learning Process of the Information and Communication Technology and Computer Science Subjects in Lower Secondary Schools in Albania in Front of International Facts and Trends

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Abstract: The specifics and the broad content of the Information and Communication Technology (ICT) and Computer Science (CS) subjects dictate various problematic on the process of teaching and learning. In the large set of components that affect the process, one of the most important components is the methodology used in teaching and learning. In the teaching process of ICT and CS subjects the use of different methods for different issues is inevitable. Today the ICT and CS subjects are taught and learned based on various methods. Some of them are unsuitable for successful teaching-learning whereas others may bring success in certain learner's groups (lower secondary school). Didactic of Informatics is not yet internationally consolidated and still is a matter of discussions. The subject of this paper is mostly the actual situation of Albania and partially how to improve the process of teaching ICT in lower secondary schools. Herewith are taken in the analyses the ratios regards to the methodology, content and technology in best performing countries, also the key factors of their success.

1 INTRODUCTION

In our age, Computer Science (CS), Information Technology (IT) and Information and Communication Technology (ICT) are developing so fast. Nowadays there are modern and new prospective about Information and Communication Technology skills.

Every civil society in worldwide needs more and more Commuter Literate, Technology Literate and Digital Literate persons. ICT specialists, Advanced Computer Users and Basic Computer Users are significantly increased during last years, but nevertheless the world wide labor market is still hungry for them.

Globally speaking, the ternary education is doing the most important part in preparation of the employer category that is mentioned above.

If we start before ternary education to introduce in a formal way creating ICT literate people, the results on quality and quantity terms will be much better.

In many countries the computer literacy is now subject of early stages of educational process. Even in some countries ICT literacy is formally introduced in preschool system.

In my country, Albania, ICT is a compulsory subject since grade 7 (age 14-15), according to national curricula of public schools.

The problems that I evidenced in the teaching and learning process were directed to many aspect of this process. Sometime the teaching process totally failed as sake of many factors such as; infrastructure, teaching sources and so on. However the main reason was the methodological failure. The teaching and learning process of ICT subjects is completely different from that of teaching other subjects (i. e. mathematics, physics or biology). This process is complexes, difficult and problematic also in international level, but certainly there are also very good successful experiences in the teaching and learning process all around the world. Being focused in Methodologies, this paper will try to evidence those good experiences.

There are taken in account countries which are in top of the PISA List [i].

Albania has participated in PISA tests three times, in 2000, 2009 and 2012. The results of Albania are analyzed and compared in front those countries.

2 STATUS QUO OF ICT SUBJECTS

2.1 Albanian Educational System

The structure of the Albanian Educational System is briefly described here with its specifics and terminology. Elementary education is compulsory (grades 1-9), but most students continue at least until a secondary education. Students must successfully pass graduation exams at the end of the 9th grade and at the end of the 12th grade in order to continue their education. The literacy rate in Albania for the total population, age 9 or older, is about 93%. Most schools are public and financed through the government, but recently several private schools of various levels have been opened. There are about 5000 schools throughout the country. The academic year is divided into two semesters(terms).
The structure of education is divided into these steps:

Preschool education (Kindergarten): 1–4 years
Primary education (9-year): 9 years (8 years prior to 2008)
Secondary education:
Regular (middle or gymnasium or high school): 3 years
Vocational or Technical (technical, artistic): 2–5 years
Tertiary education:
Bachelor and Master Degrees (of 3 years and 1.5–2 years respectively
Quaternary education (PhD, Doctoral Studies): 3 yearsii.

Formal ICT education in Albanian secondary schools includes grade 7, 8 and 9, respectively one separate subject in each grade, which is called “Informatics”.

As a lecturer of didactic of informatics in Shkodra University “Luigj Gurakuqi” (Albania), I participated in many secondary school classes in my city and assisted in many classes of ICT subject “informatics”.

2.2 Actual Facts about ICT Subjects

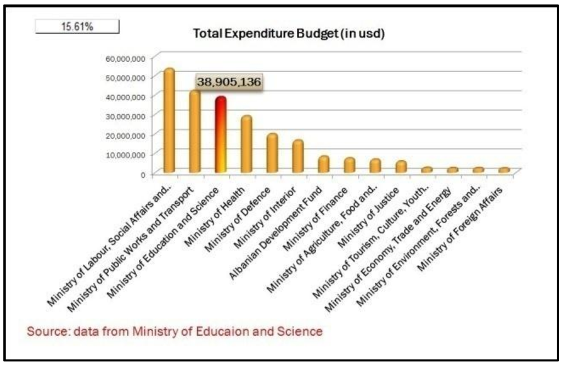
In order to scan the problematic of ICT subjects in Albanian secondary schools, last year I made a survey study during the first term of academic year 2012-2013, from September to October 2012. The survey is made in Shkodra district (one of the biggest district of Albania, in north-west Albania).
This survey can give a good overview regards to:

1. The actual situation of ICT infrastructure in secondary schools. (See subsection 2.4 for more details)
2. Teacher Background, Training, Distribution. (See subsection 2.5 for more details**)**
3. Curricula (Main Objectives) (See subsection 2.6 for more details)
4. Teaching Methodology (See subsection 2.7 for more details)

The survey is realized by contacting 85 secondary schools (90% of total schools in Shkodra district), by paying concrete visits on secondary schools in Shkodra district, interviews with directors(principals) of schools, telephone interview of directors of schools, interview of ICT teachers of schools. There are made also interviews to pupils of secondary schools.
E-mail reports from every school (ICT teachers or schools directors) are written.

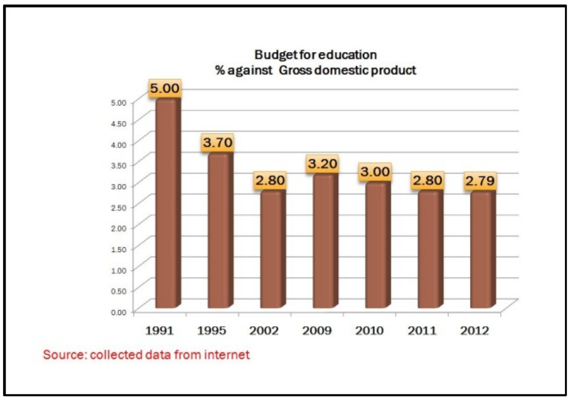
2.3 Financial Facts

During 2012 the total budget for Ministry of Education in Albania was 38.905.136 USD. This amount represents 15.6% of the total budget. This budget was 2.79% of the total amount of the GDP. Finland (one of top level countries in PISA list) has 6% budget of total GDP for education purposes. (See figures 2.3.1 and 2.3.2).



Source: data from Ministry of Educaion and Science

Figure 2.3.1: Education Budget of Albania in years.

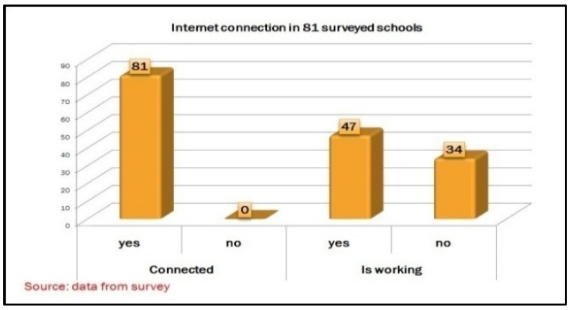

Budget for education
% against Gross domestic product

Source: collected data from internet

Figure 2.3.2: Education Budget in % against GDP.

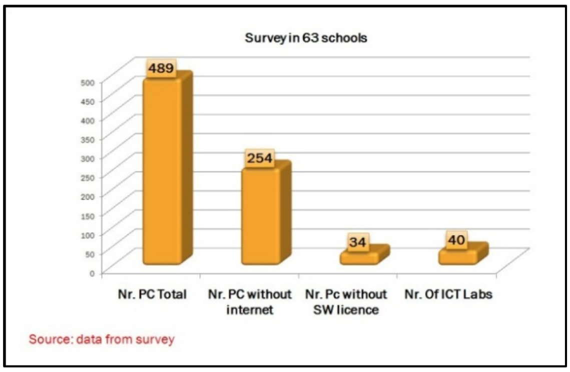
2.4 Infrastructural Facts

Talking about infrastructure in Albanian secondary schools we will see below components like internet connection (see figure 2.4.1), number of computers per pupils (see figure 2.4.2), number of ICT laboratories per pupils and other equipment (see figure 2.4.3).


Internet connection in 81 surveyed schools

Source: data from survey

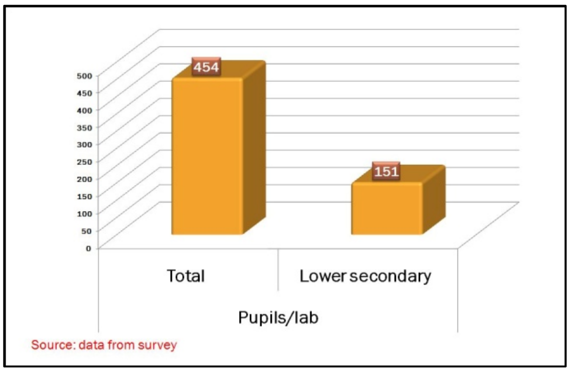
Figure 2.4.1: Internet connection in 63 schools in Shkodra district.


Survey in 63 schools

Source: data from survey

Figure 2.4.2: Total number of computers, computers connected to internet, missing licences and number of labs.

It is true that 100% of District schools have the internet infrastructure, but almost the half of it is not functional and the schools do not have capacities to maintain internet access. Even Local Office of Ministry (DAR) has no such capacities in regional level.

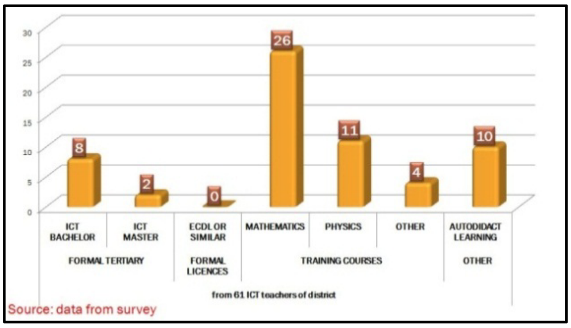


Source: data from survey

Figure 2.4.3: Number laboratories per pupils.

2.5 Teacher's Training

Talking about teacher training, it is evident that teachers have no training concerning didactic aspects. There is a need to break the cycle of learning by heart and passive learning activities. In Albanian secondary schools, It is strongly needed to move towards more learner-cantered and interactive pedagogical approaches, concerning ICT subjects. The development and implementation of a comprehensive in-service training program for ICT teachers and school administrators is a necessity of the moment.



Source: data from survey

Figure 2.5.1: ICT teacher background in Albanian secondary schools.

2.6 Curricular Aspect

About aspects of curricula, the ICT is taught and learned as a separate subject. There is no application of ICT in Subject Areas. There is no presence of ICT across the Curriculum. The secondary school curriculum does not reflect the ICT Specialization as an applied element to prepare pupils for a profession. In Basic literacy have significant missing contents such are database concepts, ethic and social issues and carriers in ICT.

2.7 Methodology

In Albania we have evidenced (based on the study survey mentioned above) the predominance of teacher-centered methods.Those methods were used in early pre-technology stages, also in international level, let's say 10-15 years ago. That is a rudiment of communism regime of Albania. Most of today teachers are educated under the strict methods dictated from regime structures. Most of ICT teachers are math teachers which did a ICT trainee, but the way that they teach math dictate also the way they teach ICT. The dominant method is so called ERR method (Evocation Realization Reflection).

3 TRADITIONAL-EARLIER TEACHING METHODS

Method represents how the content is transmitted to the pupil and how the class is organized.

Pre technical area of teaching in the teaching and learning process can be compared with the situation where the teacher is the sender or the source (of knowledge, concept ...), the study material is the information or message to send, and the student is the receiver of the information (Temechegn Engida, 2011). Regarded to ICT subjects, the content is much more unstable. The subject groups of teaching are not yet stable (different schools introduce ICT subjects in different grades, different countries have different ICT policies for schools). The teacher centred method can be successful method in other scientific subjects, but not in ICT and CS subjects.

The technology era dictated the new approach in teaching process everywhere. The technology is now an inevitable aspect of teaching and learning process. Source of knowledge is now a set of environments, tools and systems. As a result the learner can be an interactive subject of the process, not just the receiver of knowledge.

4 NEW APPROACHS AND METHODS

Nowadays there is a democratization of knowledge and the role of the teacher is changing to that of facilitator (Damodharan and Rengarajan, 2000).

Based on experience of top countries in PISA list (PISA, 2009) (Finland, Canada, China etc.) and based on formal of UNESCO recommendations is made a list of new methods and approaches on how to organize the process of teaching in ICT and CS classes (Buettner et al., 2002; Grace et al., 2011).

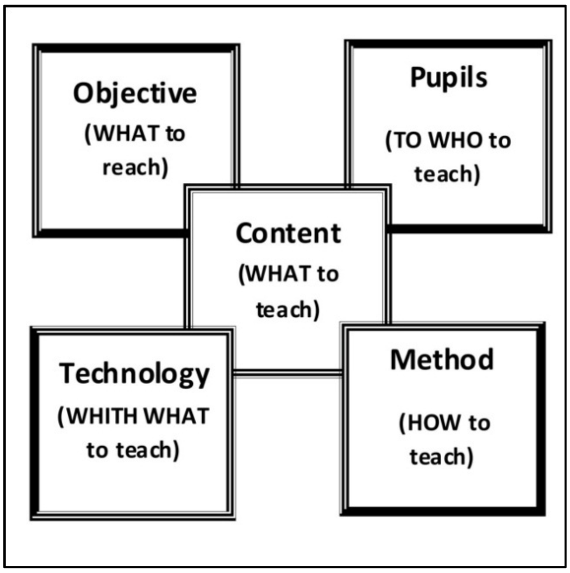
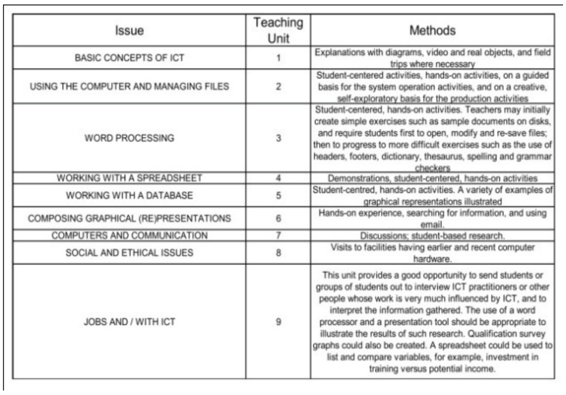


Figure 4.1: Components of teaching process.



Issue	Teaching Unit	Methods
BASIC CONCEPTS OF ICT	1	Explanations with diagrams, video and real objects, and field trips where necessary
USING THE COMPUTER AND MANAGING FILES	2	Student-centered activities, hands-on activities, on a guided basis for the system operation activities, and on a creative, self-exploratory basis for the production activities
WORD PROCESSING	3	Student-centered, hands-on activities. Teachers may initially create simple exercises such as sample documents on disks, and require students first to open, modify and re-save files; then to progress to more difficult exercises such as the use of headers, footers, dictionary, thesaurus, spelling and grammar checkers
WORKING WITH A SPREADSHEET	4	Demonstrations, student-centered, hands-on activities
WORKING WITH A DATABASE	5	Student-centred, hands-on activities. A variety of examples of graphical representations illustrated
COMPOSING GRAPHICAL (RE)PRESENTATIONS	6	Hands-on experience, searching for information, and using email.
COMPUTERS AND COMMUNICATION	7	Discussions; student-based research.
SOCIAL AND ETHICAL ISSUES	8	Visits to facilities having earlier and recent computer hardware.
JOBS AND / WITH ICT	9	This unit provides a good opportunity to send students or groups of students out to interview ICT practitioners or other people whose work is very much influenced by ICT, and to interpret the information gathered. The use of a word processor and a presentation tool should be appropriate to illustrate the results of such research. Qualification survey graphs could also be created. A spreadsheet could be used to list and compare variables, for example, investment in training versus potential income.

Figure 4.2: Teaching methods suggested for each unit in Basic ICT literacy.

5 RESULTS

In this section we describe some general results.

This paper takes in evidence the real situation of the Information and Communication Technology and Computer Science subjects in Albanian secondary schools.

It is evidenced that the government structures have introduced efforts to improve the process, but there are aspect of process like methodologies and teacher training that is not done enough.

In aspects of infrastructure is evidenced the most important problem which is the Maintenance of everything created. In order to suggest the results to the Albanian Educational System and trying to standardize the process of teaching and learning is evidenced the best international experience (especially in terms of methodology).

Is evidenced the lack of trainee of teachers about didactic, technological and content aspects, in order to surpass the gaps in process of teaching.

6 CONCLUSIONS

All or almost all secondary schools have computer labs with Internet access; however the number of computers, the quality of the maintenance and the Internet bandwidth are not adequate to meet student demands for ICT and CS classes. There is a need to increase the number of PCs, labs and other equipment.

Methodology is the most problematic, deficient and outdated aspect in the process (Teo and Wong, 2000). In Albania almost nothing is done from didactic specialists and from responsible institutes. It is an emerge need to move towards pupils – centered methods and multiple methods of organizations of teaching process. As final conclusion this paper points out the need to standardize methodologies in the community of teachers in Albania and wider.

Based on experience of Finland we can say that the key of success is the formal education and informal training of on duty teachers, autonomy of schools on ICT priciest and the autonomy of ICT teachers. In Finland there is not a National Curricula about ICT subjects. Also England (Kargiban and Kaffash, 2012) decided to skip National ICT Curricula for secondary schools. Schools and teachers can decide regard to curricula and methodologies.

Strategic goals must unify vision to fully integrate ICT and SC in the secondary school system and clearly include measurable curricular/pedagogical goals and objectives.

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Highlights from PISA 2009: Performance of U.S. 15-Year-Old *Students in Reading, Mathematics, and Science Literacy in an International Context.*

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[i] This is a list of countries by student performance. The Programme for International Student Assessment (PISA) published a report on the performance of students across countries and in a couple of cases, cities. The report has recently included more countries outside of the OECD member countries. The 2009 report, the latest one, is used in this list and includes a more extensive report into the reading ability of students.

[ii] http://en.wikipedia.org/wiki/EducationinAlbania

The Development of an e-Portfolio for Competency based Training Assessment for a Malaysian Skills Diploma Program

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Keywords: Competency Based Training, Electronic Portfolio, Skills Training Program, Formative Assessment.

Abstract: This paper presents a comprehensive Electronic Portfolio (e-Portfolio) Framework developed for Competency Based Training (CBT) assessment in a Malaysian Skills Diploma Program which is certified by the Ministry of Human Resources in Malaysia. The proposed framework is adapted from an existing assessment system, which was outlined by the Ministry of Human Resources with the addition of other features from current E-Portfolio technologies. The aim of this study is to present a new comprehensive framework that contains a combination of e-portfolio applications that align with the current methodology of CBT assessment as a blended approach to formative assessment. Senior officers at the Ministry of Human Resources, Principals and Instructors of Training Institutes have been questioned via the medium of email based interviews to establish their views on the need for this kind of e-Portfolio as well as the possible constraints that would be faced. All interviewees agreed that the e-Portfolio is well suited for implementation as an evaluation method to improve the IT skills of the students. However, they also highlighted constraints that should also be considered before implementation to ensure this system will be effectively installed and completely functional.

1 INTRODUCTION

Competency-Based Learning/Training (CBL/T) is a current method used to bring together the gap between learning in educational settings and future workplace performance, which represents a challenge for institutions of higher and further education (Sluijsmans et al., 2006). In competency-based learning methods, the models and learning strategies used must be able to encourage reflection and reactions from students in an effort to solve the problems and challenges they face during training. The students are often tested with problems that require skills and knowledge based on previous experience or what they have learned. Competence is important so that students will master the skills needed in 'real world' industry (Bastiaens, 2010). Technically, in CBT students need to collect proofs of their skills during training so that their competence can be recognised. Normally in developing countries, evidence collection is done manually through the compilation of a paper based file. Research into the use of electronic portfolios in developed countries in higher and further education indicates that there are potential benefits to the use of e-portfolios. The main aim of the e-portfolio is to encourage inclusive learning with the use of ICT technology and promoting learning ownership for students or trainees as well as instructors. This paper proposes a framework for adapting the concept of CBT in the e-portfolio for Skills Training program in Diploma Courses that allows this system to be embedded in training methodologies. There are many potential benefits to be gained through the use of e-portfolios in CBT; such as an improvement in industrial recognition of the product of students' work, encouraging an active learning environment, as well as cultivating the IT skills of students whilst completing assignments. Moreover, the instructors could also monitor the performance of students through their e-portfolio progress to take proper steps to support students who experience problems. The development of this framework can also be a guide for any institution or any parties who intend to use an e-portfolio in their training program.

2 COMPETENCY BASED TRAINING (CBT)

In Malaysia, the Skills Training Program was developed in alignment with this CBT approach. These programs were organized and coordinated by the National Vocational Training Council under the jurisdiction of the Ministry of human Resources. To implement CBT, a national occupational skills standard (NOSS) was developed. For every NOSS-based training program, the learning outcomes to be achieved are stipulated in the task profiles of the NOSS, which include performance standards to be met at the end of the training program (Sachs, 1998). The training objectives, or outcomes, are specified and made known to trainees in advance so that trainees can progress at their own optimum rate. In other words, the duration of time spent on training can be a variable but the learning outcomes to be achieved are considered to be constant (NVTC, 2001, p.8). The focus on outcomes is clearly reflected in the interpretation of the 'competency' concept that underpins the training system based on NOSS in Malaysia:

"The concept of competency focuses on what is expected of a worker in the workplace rather than on the learning process. It embodies the ability to transfer and apply skills and knowledge to new situations and environments" (MLVK, 1995, p.1).

The outcome-based orientation of the competency-based approach is usually characterized by its strong emphasis on assessment. This can be seen from an interpretation of assessment which is typically used in competency-based training as the "process of collecting evidence and making judgments on the extent and nature of progress towards the performance requirements set out in a standard, or a learning outcome" (Hager et al., 1994, p.5). By adopting the competency- based approach, the training system based on NOSS in Malaysia clearly favours an outcome-based orientation. This orientation has been accentuated by the implementation of a national skills certification system which adopts a criterion- referenced assessment approach, focusing on performances as the key basis for assessment and certification (NVTC, 2001, p.4).

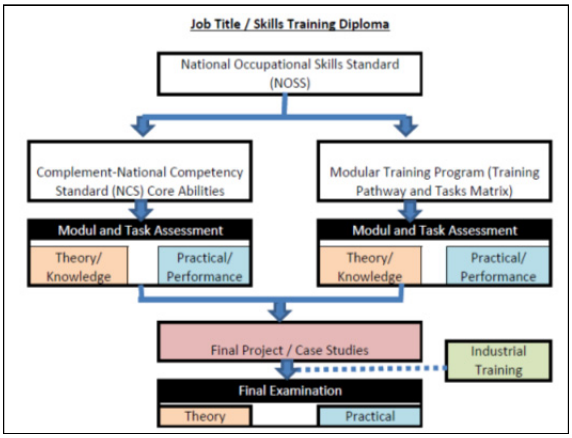

Figure 1: Existing CBT Assessment Process in Malaysia Skills Diploma Program.

Figure 1.0 shows the process of assessment in the Malaysian Skills Training Diploma. Each student must meet the criteria of competence in modular training programs as well as in the complement/elective programs. They also need to accomplish the final project and six months of industrial training before they are qualified to be awarded with the Diploma certificate. All assignments, documents and evidence of competencies are compiled in a large file called the student portfolio.

3 E-PORTFOLIO

e-Portfolios can be defined as "a personal, web-based compilation of work, assignment feedback, and reflection used to indicate key skills and achievements in a variety of contexts and time periods" (Barrett, 2005); (Reardon et al., 2005); (Turhan and Demirli, 2010). This collection consists of elements of text, graphics, or multimedia which can be accessed through a web site or other electronic media such as CD-ROM or DVD. The learning portfolio is a flexible, evidence-based process that combines reflection and documentation. It engages students in ongoing, reflective, and collaborative analysis of learning. It focuses on purposeful, selective outcomes for both improving and assessing learning. In vocational and education training which employs the Competency Based Training approach, few countries have implemented this application as part of their e-learning education support program. The use of a portfolio is an alternative form of learning and assessment that is particularly attractive to vocational educators because it includes the assessment of active learning and performance rather than the mere recall of memorized facts (Turhan and Demirli, 2010). Turhan & Demirli (2010) reported from their study of vocational education teachers' and students' perception of the use of e-portfolios in the United Kingdom, Denmark, Romania and Turkey showed that both teachers and students found the e-portfolio process was necessary in vocational education as part of the learning session. The outcomes of a Leonardo da Vinci project (MOSEP - More self-esteem with my ePortfolio) showed that E-portfolios can be used as a technology supported learning method for the documentation of competency development (Hallam, 2008). This project outlined a new training concept for teachers and tutors using open source e-portfolio software tools.

4 E-PORTFOLIO IN MALAYSIAN SKILLS TRAINING PROGRAM

The Malaysian Skills Certification Program does not currently make use of any Virtual Learning Environments (VLE) such as e-portfolios or any training applications implemented in public or private training institutions. However, some countries such as the USA (Abrami et al., 2008); Lorenzo et al., 2005) UK (Madden, 2007) , Australia (Gerbic and Maher, 2008); (Hallam, 2008), Portugal (Queirós et al., 2011) and the Netherlands (Bastiaens, 2010) have adopted various types of specialized VLE for students in higher education including the Vocational Education Training (VET) sector enhance the quality of the program and to appeal to parents and prospective students. To obtain views regarding the development of e-portfolio in Malaysian Skills Training Programme, an interview was conducted as part of this project to assess the opinions of five senior officers from the Department of Skills Development, Malaysia Ministry of Human Resource, two managers of Private Accredited Centre that run Malaysian Skills Training Program under the Department of Skills Development; and three instructors cum verifier officers of Accredited Centre that teach Skills Training Programme (two were from the private institutions and one was from Public/Government Institution).These interviews were conducted via email and the questions related to an evaluation of current methods of portfolio documentation, views on the need for a VLE, and any barriers to implementation that they could predict. According to senior officers, Department of Skills Development (DSD) Ministry of Human Resource at the moment is in the process of developing a system of ICT applications, which are known as the National Skills Credit Bank System. This system intends to upgrade the Skills Training Program to adopt information technology into the learning and training methodology (Dollah et al., 2012). While the instructors and the principals stated that their campus, currently has not applied a VLE, they do utilize a common system for recording student grades and observations on the performance of trainees (Abd Aziz and Haron, 2012); (Zulkefli et al., 2012). Analysis of the interviews highlighted several reasons why e-portfolios should be introduced to trainees. The requirements were based on the situation and circumstances as follows (1) To upgrade the skills training program to be at par with professional training programs that are recognized by well-known organizations in and outside the country; (2) To promote skills training to youth and adults with increasingly interested in the field of information technology in line with the current technology; (3) To facilitate monitoring of the certification body so that the training process and requirements of the learning outcomes of the training centers' and the trainees will be conformed according to the standard set.; and (4) To facilitate the training program in providing promising opportunities through links with other programs in other institutes as options for the trainees' further education path.

Moreover, according to the instructors, teenagers now prefer a more flexible training environment and on-demand learning. They prefer reading materials and references that give more insight into professional reality than traditional textbooks. Thus, e-learning has the potential to motivate students to explore the internet to find constructive and beneficial information relating to their learning rather than wasting time visiting social sites and playing video games (Zulkefli et al., 2012). The Principal of the training center also agreed to implement e-learning such as the e-portfolio in the training system mainly to provide the performance report and results of the trainees to parents or a third party. This system will also maintain the quality of learning and training by upgrading and enhancing the training methodology in line with current learning technologies. Regarding the costs to be considered, they understand that in order to implement any kind of reform process, costs and risks will certainly exist. These costs can be considered according to the needs and current situation (Abd Aziz and Haron, 2012). In conclusion, the results of interviews with various parties involved in the skills training program showed that there is general agreement that the e-portfolio should be implemented in the program to the advantage of trainees, instructors, the awarding body, parents and any other parties that are directly or indirectly involved with skills training based education. Furthermore, they suggested other kinds of e-learning methods, which may have various benefits for instance a learning management system or mobile learning.

4.1 Proposed CBT Blended Assessment Model

The purpose of developing this E-portfolio is to enhance current assessment methodologies in the Skills Training Program to a method called CBT Blended Assessment. This blended assessment will combine online participation as well as face-to-face evaluation by students. For online participation, students have to create an electronic portfolio in the system provided. Figure 2.0 shows components of assessment that will be involved in the E-portfolio system in CBT Blended Assessment Model.

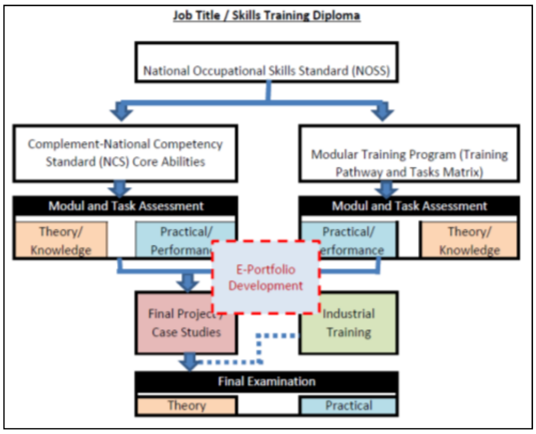

Figure 2: Proposed CBT Blended Assessment Model in Malaysia Skills Diploma Program.

4.1.1 e-Portfolio Development Framework

The purpose of the CBT e-Portfolio Framework development is to pave the way for the development of well planned and organized specific e-portfolio for CBT. A framework of e-portfolio based CBT is developed based on criteria of CBT. This framework consists of three elements which are **modules and task performance objectives**, **performance assessment** and construction of **trainee's e-portfolio** for each module.

Module and Task Performance Objectives*:** Each module has several tasks that should be accomplished by the trainee in order to achieve competence. The modules have certain performance objectives as well as containing tasks. These objectives will be aligned with a skills and competencies matrix for respective modules. Trainees must comprehend this matrix in order to plan the progression of their work. ***Performance Assessment: Each module must have a complete set of performance assessments to audit skills competencies. This assessment must allow formative as well as the compulsory summative assessment. A *formative evaluation* (sometimes referred to as internal) is a method for judging the worth of a program while the program activities are *forming* (in progress). CBT learners must know the work process in solving a given task. Therefore, they have the responsibility to work through the process in the correct order. Progress must also been evaluated and commented on with the aim of raising learning standards. ***Trainee's e-Portfolio:*** After completing the phases such as identification of skills competencies and assessment needs, trainees can begin to construct a collection of pages for each module. Each module collection must contain the skills matrix, progress of work and the completed final work. The skills matrix is also used as a performance rubric or field monitor for the instructor to identify the level of competence of trainees for each given assignment. In the student's personal e-portfolio account, they must include all documentation, instructions and resources. Table 1.0 shows an example of evidence required in the e-portfolio.

Table 1: Examples of Contents in e-Portfolio.

Types of Content	**Content**
Instruction	Question Paper, Work sheet
Documentation	Skills Matrix, assignments, Project Paper, On Job Training log book,
Resources	Video, audio, images, industry testimonials
Personal	Profiles, Plans, Resume, Groups, links

5 RESULTS OF PILOT TEST

A three months pilot test of E-portfolio system had been implemented to a group of students from one private Skills Training Institute in Malaysia. The pilot session involved 23 students and 2 instructors which are from Diploma Skills in Culinary Art

Program. The scope of this session begins with both student and instructor will sign up for a personal account and fill the basic information required, instructor then publish a performance assessment question with dates of submission/progress, student starts to develop plan using 'PLAN' function in the system and insert the dates given as well as the other content like materials for assignment preparation, student place their progress of work in their personal E-portfolio account and finally get feedback from the instructor. From the analysis based on user statistics in E-portfolio monitoring system, all 23 students were successfully signed up on to the system. However, only 15 students were involved in assignment tasks with only 60% from them submitted until final submission. Then, students were given a questionnaire that asking their opinion about how they perceived about the system. From 23 students overall, only 8 students were filled in the online questionnaire provided. Below are the summary of the participation in the pilot test session.

Table 2: Summary of Students' Participation in e-Portfolio Pilot Test.

Activity	**No of Student Participated**	**Percentage (from total students in class)**
Signed Up Process	23	100%
Reflect on the assignment post	15	65%
Take part in review process	8	35%
Final Submission	9	39%
Fill up the online questionnaire	8	35%

Result from questionnaire is presented in the histogram (Refer Figure 3.0). Majority of these graphs were representing the modes of frequency after accumulating the result from sub-questions. There are eight main questions asked which are Perceived Usefulness, Perceived Ease of Use, Computer Self-Efficacy, Image, Facilitating Conditions, Competence Expectancy, Perceived Playfulness and Behavioral Intention in 5 scales rating questionnaires *(1:Strongly Disagree, 2:Disagree, 3:Neither agree or disagree, 4:Agree, 5:Strongly Agree).*

Overall, by refer to the histograms of Perceived Usefulness, Image, Competence Expectancy and Behavioral Intentions, majority of students agreed that the E-portfolios are useful to facilitate the assignment completion and recognize the key competencies required for the module. In addition, they also agreed that by using this system, they can enhance their image into a technologically advanced student. Ultimately, they decided to continue to use the system during the course and will invite their friends to join using this system in the future. However, for technical support issues, only some of them felt that there is a support team available to assist when in problems while others favor neutral. The same result shows on issue Perceived Playfulness which was only partially felt that by using this E-portfolio system will adds more pleasure and joyful during the training courses.

On the other hand, it can be found that most of the students were having moderately skills in computer usage and application. This was evident when many of them choose intermediate for Computer Self-Efficacy issues. In the same case, the issue of Perceived Ease of Use also showed moderate rating for mainly students. This clearly indicates that with low skills in computer applications, this system viewed rather difficult to use during training.

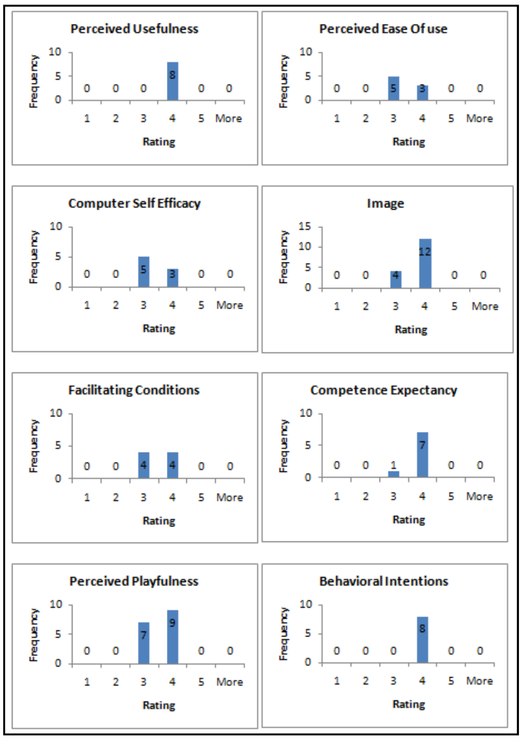

Figure 3: Result of questionnaires.

6 IMPLEMENTATIONS ISSUES AND CHALLENGES

Senior officers stated that the main constraint to implementation of a VLE or online learning for these training programs is difficulty in getting internet access services in remote areas such as Sabah and Sarawak and the upstream side of the village in the peninsula. The instructors' opinions were that any kind of system could be implemented but it would require a longer time to familiarize trainees to internalize the system due to the attitude and skills or weaknesses in the trainees themselves in terms of adopting these technologies. Principals also stated that in order to implement the reforms, many things need to be considered by various parties, such as time, cost and manpower. All of which has to be approved by various levels of meetings with stakeholders. In addition, the system development process also requires review and comprehensive study to produce a system that really functions and satisfies the end user. Therefore, these constraints should be considered before making the decision to implement e-learning. These are summarized as follows: (1)The supply of hardware resources such as computer equipment, internet, network, servers and other hardware involved in every centre that participates; (2)The provision of software and applications must be easy to develop and maintain as well as low in cost if licensed; (3) Intensive training to trainees and all institutional personnel or departments which will be involved with the system; (4) Moral and financial support from the stakeholders and management; and (5) Costs like resources, manpower and time periods should be considered from the beginning of a process of planning, implementation, testing up to the assessment of effectiveness.

7 CONCLUSIONS

This paper has presented proposed changes to the current evaluation model in Malaysia Skills Training Diploma to a new CBT blended assessment model which adopts the concept of an e-portfolio. This e-portfolio system has received positive feedback from various groups such as senior officers at the ministry, principals and instructors of the training institutes. Numerous people have proposed that there may be advantages to the student like time and cost saving, enhancing student's active learning and giving students access to the latest learning technology. Although there are several constraints that need to be addressed and taken into account such as the high cost of short and long term investment for the facilities and equipment, lack of student's and instructor's awareness as well as the political intervention, these people believed that the new model would be of benefit and successful. Proposals to develop e-portfolios have full support from all parties involved with the Skills Training program in Malaysia. This system will hopefully help the trainees to be more reflective in their training and deepen the objectives of their courses.

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Fostering Scientific Reasoning Skills through Interactive Learning Tasks

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Abstract: Scientific reasoning is a key skill in academic contexts and may be trained with interactive learning tasks, that require learners to explicitly give reasons for their solution. We provide a general, mathematically motivated algebraic model for reasoning tasks that enables computer-based analysis of answers and feedback generation, especially in the case of tasks that have distinct permissible correct solutions; furthermore we present our ready sample implementation guided by that model.

1 INTRODUCTION

Scientific reasoning has been known to be an important skill for university students in order to obtain higher academic degrees, such as master's and PhD degrees. In 1933 *The American Physics Teacher* featured an article that links better ability to solve tests that involve reasoning to higher achieved academic degrees (Worthing, 1933).

Zimmerman considers the study of the development of conceptual knowledge in particular scientific domains along with the study of the reasoning and problem solving strategies involved in hypothesis generation, experimental design, and evidence evaluation to be the two main approaches to the study of scientific thinking and finds that these two approaches distinguish different connotations of scientific reasoning (Zimmerman, 2000). Domain-specific scientific reasoning typically requires the use of conceptual knowledge of a particular scientific phenomenon (Zimmerman, 2000). It has been studied among others in the domain of physics, where individuals had to use their conceptual understanding to generate solutions to tasks, but were not required to make observations, evaluate evidence, or conduct experiments (Zimmerman, 2000).

Ziegler (1990) studied solution rates for the Wason selection task (1968) for abstract implications and found an improvement of correct solution rates after training measures (Meiser and Klauer, 2001). Klauer et al. (1997) researched interference effects regarding propositional reasoning and found a significant effect of training on the number of correct solutions (Meiser and Klauer, 2001). Klauer et al. (2000) compared the effects of different training conditions on propositional reasoning: both abstract semantic training and domain-specific semantic training were significantly more effective than both syntactic and no training, whereas there were no significant differences between abstract and domain-specific training (Klauer et al., 2000).

A study conducted by Cheng et al. (1986) suggests that human reasoning relies rather on available inference schemes than on content-independent syntactic rules (Meiser and Klauer, 2001). Klaczynski et al. (1989) showed that better solution skills in one domain may be transferred to other domains if the training measures led to the acquisition of new mental representations of the logical connectives, which may be achieved by either abstract training or content-oriented training where participants are confronted with contradictions between their previous representation and the formal correct meaning of the premises (Meiser and Klauer, 2001). Content-oriented training measures that do not challenge previous representations showed no transfer effects (Meiser and Klauer, 2001; Klaczynski et al., 1989). Therefore it is important to challenge errors and misconceptions in order to train scientific reasoning skills. This may be achieved by training measures that give interactive feedback that points out possible contradictions between the mental representations of the logical connectives and their formal correct meaning. Suitable training measures may combine answer-until-correct or multiple-try feedback strategies with knowledge of performance feedback, knowledge of result feedback and elaborated feedback, such as knowledge of the location and count of mistakes (Narciss, 2008).

1.1 Interactive Learning Tasks

An interactive learning task consists of two main parts: the question or problem to be solved and its solution (Proske et al., 2012). Such a task is designed such that the series of cognitive operations and actions conducing to its outcome lead learners to be actively engaged in knowledge construction, and such that the learner may interact with a system or a person during the execution of the task in a way that supports in performing the necessary cognitive operations and actions (Proske et al., 2012). Working on interactive learning tasks may help in overcoming obstacles or in correcting incorrect solution steps, thus interactive learning tasks provide mastery experiences and foster learners' motivation (Proske et al., 2012).

Design Requirements

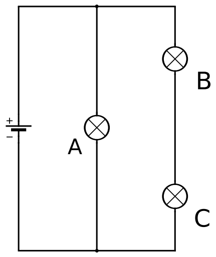
In general, interactive learning tasks should give students opportunities for repetition and correction, tutor learning task processing, and reciprocally react on learners' actions by providing feedback or other means (Proske et al., 2012). Furthermore "instructions should enable students to apply basic scientific principles flexibly, to explain or predict diverse phenomena, and to become good problem solvers and independent learners." (Reif and Scott, 1999)

In order to train scientific reasoning skills with an interactive learning task, the task must involve scientific reasoning and provide a possibility for the learner to see at which points their own reasoning is not correct in the sense of proper scientific reasoning. Thus interactive learning tasks should provide interactive feedback that not only gives information whether the solution is correct or incorrect, but also which parts of the solution contain mistakes. This should be done by providing multiple response steps with elaborated feedback components that guide the learner toward successful task completion without offering the correct response immediately (Narciss, 2008). This feedback may be given either by automated solutions or by human tutors.

1.2 Example Learning Task

We want to give an example of a learning task that involves scientific reasoning in the domain of physics.

Problem P:

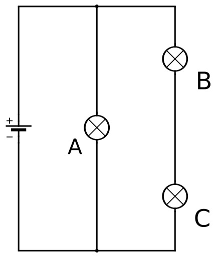


Consider the schematic to the left!
How do the luminosities of the bulbs A, B, and C relate to each other, if all three bulbs are of the same kind?

Solution. Bulb A has higher luminosity than the other bulbs and the luminosities of bulb B and bulb C are equal.

In order to give the correct solution, a student unfamiliar with such problems has to extract information from the schematic, that the bulbs B and C are connected in series and that the bulb A is connected in parallel with the bulb chain BC. Afterwards the student has to use conceptual knowledge regarding both kinds of connections in order to infer the luminosity qualities of the bulbs. On the other hand, a student familiar with such problems may be able to give the solution right away. Thus the problem has to be modified in order to train scientific reasoning:

Problem Q:



Consider the schematic to the left!
How do the luminosities of the bulbs A, B, and C relate to each other, if all three bulbs are of the same kind?
Give reasons for your answer!

Although the modified problem is well defined, it is quite cumbersome to give the solution beforehand, because there are lots of different rationales that infer the solution from the problem all of which are correct. Thus a supervisor has to undertake the tiresome and arduous task of checking each student's answer for factual correctness and completeness by following the given reasoning steps and checking their soundness.

1.3 Computer based Interactive Learning Tasks

Reif and Scott (1999) give an example computer based PAL[1] tutorial for Newton's law and its applications regarding basic Newtonian mechanics. Their computer based system offers three modes of operation: the student may be coached in implementing

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[1] Personal Assistant for Learning

specified actions, the student may assess and correct the work of the PAL, and the student is provided with independent practice on similar problems (Reif and Scott, 1999). All problems of the computer based PAL tutorial example by Reif and Scott (1999) involve the creation of a diagram of all forces relevant to the mechanical system as the key step towards the solution. Although there is some non-linearity in the construction process, there is only a single valid diagram of the relevant forces per problem, which makes it easy to decide whether there are components missing and whether there are misplaced arrows or errors in the calculations – it suffices to compare the student's work against the correct solution of the problem, and to give feedback accordingly.

1.4 Reasoning in Learning Tasks

Learning tasks that require the student to explicitly do scientific reasoning as part of the solution have more than only one distinct correct answer in general: Consider problem Q. We might argue that the same voltage means the same luminosity. But we also might argue that the same current means the same luminosity. If we chose the first argument, we could say that the current through bulb B is the same as the current through bulb C, thus bulb B and bulb C are equal bright. If we chose the second argument, we would argue that the voltage of bulb B is as big as the voltage of bulb C, thus they have the same luminosity. In order to systematically give interactive feedback for learning tasks that require scientific reasoning, we need a model of reasoning. Although a complete model of scientific reasoning could be used as well, incomplete – and sometimes much easier – models that only cover those aspects of scientific reasoning that are relevant to give interactive support and to check the student's answer will suffice.

2 ALGEBRAIC MODEL OF REASONING IN INTERACTIVE LEARNING TASKS

In this section, we will provide an algebraic background model that is sufficient to generate appropriate interactive learner's feedback for scientific reasoning tasks.

The atomar entity of reasoning that we are dealing with is an assertion, and the *set of all assertions* will be denoted by A. Furthermore we will denote the two-elementary complete lattice by

$$\mathbb{L} = (L, \leq, \bigvee, \bigwedge, 0, 1)$$

and interpret 0 as false or incorrect, and 1 as true or correct.

Each implementation of an interactive learning task has a set of assertions that a learner may use in order to generate her answer. This set is called *assertion domain* and will be denoted by $D' \subseteq A$. For obvious reasons any assertion $a \in D'$ must be of a form such that it is either is true or false within the context of the learning task, thus there is a map $v\colon D \to L$ that maps each decidable assertion $a \in D \subseteq A$ to its truth value $va \in L$, and $D' \subseteq D$.

2.1 Stating Reasons as Inverse Inference

If we ask for reasons for a specific assertion we would be satisfied if we got some assertions from which we could somehow infer the former assertion. This circumstance may be captured by the following: We let n be a natural number, then we will call any $n+1$-ary relation on D an *inference rule*, i.e. I is an inference rule if $I \subseteq D^{n+1}$ for some natural number n that depends on I. We will interpret

$$(a_1, a_2, \ldots, a_n, a_{n+1}) \in I$$

such that the assertions a_1 through a_n are considered to be reasons for a_{n+1} w.r.t. I.

Of special interest are *valid inference rules*: An inference rule $I \subseteq D^{n+1}$ is called valid, if for all $a_1, a_2, \ldots, a_n, a_{n+1} \in D$

$$\bigwedge_{i=1}^{n} va_n \leq va_{n+1}$$

holds. If we have a given set of valid inference rules, we can use it to generate new correct assertions from known-to-be-correct assertions, and to verify that some given reasons are indeed sufficient for some assertions.

2.2 Using Inference Bases to Decide Correctness in D'

If we want to check whether an assertion $a \in D'$ is correct, we can use an initial set of correct assertions $A_0 \subseteq D$ and a set of valid inference rules R. We will successively extend our knowledge of correct assertions: starting with A_0 we apply all the rules $I \in R$ to all combinations of correct assertions we know and continue with combinations involving assertions we just gained knowledge of until no more new correct assertions arise. Thus we are closing A_0 under R:

$$\begin{aligned}\overline{A_0}^R = \bigcap \quad & \{A \in 2^D \mid A_0 \subseteq A, \\ & \forall I \in R,\, a_1, \ldots, a_n \in A, \\ & a_{n+1} \in D\colon \\ & (a_1, \ldots, a_n, a_{n+1}) \in I \Rightarrow a_{n+1} \in A\}\end{aligned}$$

Although we can use any such pair (A_0, R) to verify that an assertion $a \in D'$ is indeed correct, we need another property of (A_0, R) in order to know that an incorrect assertion a is indeed incorrect: We consider a pair (A_0, R) – where $A_0 \subseteq D$ and R is a set of inference rules – to be a D'*-base*, if for all $a \in D'$

$$va = 1 \Leftrightarrow a \in \overline{A_0}^R$$

This means that if we have a given D'-base we may close its set of correct assertions under its set of inference rules and use the resulting set of correct assertions to check whether an assertion $a \in D'$ from the assertion domain of the interactive learning task implementation is correct within this context. If the assertion is in the closure, i.e. $a \in \overline{A_0}^R$, it is correct, otherwise it is incorrect. An author creating an implementation of such a task now only has to give a sufficient amount of both valid inference rules and correct assertions[2] in contrast to having to enter all correct assertions from D'.

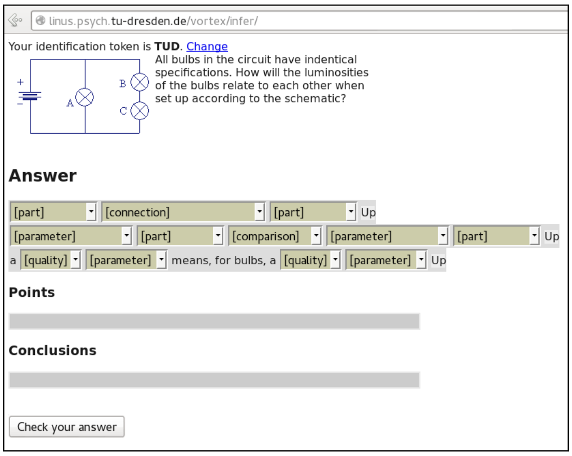
2.3 Checking Reasons for Assertions

We also want to use valid inference rules to check whether a given argumentation – which we consider to be merely a set of assertions $P \subseteq D'$ – contains reasons for all of the non-trivial and non-obvious correct assertions that it contains. Therefore we want to use a set R of inference rules, where every inference rule $I \in R$ represents a satisfactory way of arguing.[3]

Let (A_0, R) be a D'-base where every $I \in R$ also represents a way of arguing, and let $P \subseteq D'$ be a given argumentation. We further assume that $P \subseteq \overline{A_0}^R$, i.e. that all assertions from P are correct. In order to check whether the argumentation P is not missing any reasons from the assertion domain D', we will start with the trivial and obvious assertions from P, and then try to use rules $I \in R$ to successively justify new assertions from P. Thus we compute the relative closure of the empty set $\emptyset$ with regard to P under R:

$$\begin{aligned} \widetilde{P}^R \quad = \bigcap \quad & \{A \in 2^P \mid \forall I \in R, \\ & a_1, \ldots, a_n \in P \cup (\overline{A_0}^R \backslash D'), \\ & a_{n+1} \in P : \\ & (a_1, \ldots, a_n, a_{n+1}) \in I \Rightarrow a_{n+1} \in A\} \end{aligned}$$

Clearly, the set $\widetilde{P}^R$ consists of those assertions from the argumentation P that are either trivial or obvious, or that may be satisfactory justified by other given assertions. In other words, the set $P \backslash \widetilde{P}^R$ contains the assertions from P for which the student should give more reasons.


linus.psych.tu-dresden.de/vortex/infer/

Your identification token is **TUD**. Change

All bulbs in the circuit have indentical specifications. How will the luminosities of the bulbs relate to each other when set up according to the schematic?

Figure 1: Screenshot of a sample implementation of problem Q.

3 IMPLEMENTING AN INTERACTIVE LEARNING TASK ON SCIENTIFIC REASONING

In order to demonstrate that our algebraic modeling approach is fruitful we have developed and implemented an interactive learning platform that works in a standard Java and JavaScript enabled web-browser. Below we will sketch how an interactive learning platform web page as seen in figure 1 can be created for problem Q. The interactive learning web page contains a description of the problem, along with a template kit that can be used to construct sentences, which subsequently can be dragged into separate areas, one for the answer of the question and one for reasons that lead to the answer. After entering the answers and reasons the student can request the web site to check the answer, in which case the student is provided with information whether each point is correct, whether the student should give more reasons for each point, and whether there are points regarding the schematic or the underlying physical laws missing.

3.1 Working with the Algebraic Model of Reasoning

First, we need to choose a good assertion domain D' for the learning task. Any number of sentences

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[2] Those assertions do not necessarily have to be from the assertion domain the student is composing her answer from.

[3] Note that 1-ary inference rules $I \subseteq D^1$ represent obvious or trivial assertions, since they are contained in the closure of the empty set $\overline{\emptyset}^R$.

Table 1: Sentence template for the description of the schematic.

bulb A	is serial connected with	bulb A
bulb B	is connected in parallel with	bulb B
bulb C		bulb C
bulb chain BC		bulb chain BC
the battery		the battery

Table 2: Sentence template for the comparison of circuit element parameters.

the current through	bulb A	is smaller than	the current through	bulb A
the voltage of	bulb B	is as big as	the voltage of	bulb B
the resistance of	bulb C	is bigger than	the resistance of	bulb C
the input power of	bulb chain BC		the input power of	bulb chain BC
the luminosity of	the battery		the luminosity of	the battery

Table 3: Sentence template for the relations between the parameters.

a	smaller	current	means, for bulbs, a	smaller	current
	bigger	voltage		bigger	voltage
		resistance			resistance
		input power			input power
		luminosity			luminosity

Table 4: Examples for the inference rule set of our implementation of problem Q.

rule name	*example reasons*	*example conclusion*
schematic to comparison	bulb B is serial connected with bulb C	the current through bulb B is as big as the current through bulb C
comparison transitivity	the voltage of bulb A is as big as the voltage of bulb chain BC	the voltage of bulb A is bigger than the voltage of bulb B
	the voltage of bulb chain BC is bigger than the voltage of bulb B	
parameters & comparison	the voltage of bulb A is bigger than the voltage of bulb B	the luminosity of bulb A is bigger than the luminosity of bulb B
	a bigger voltage means, for bulbs, a bigger luminosity	
comparison inversion	the voltage of bulb A is bigger than the voltage of bulb B	the voltage of bulb B is smaller than the voltage of bulb A
parameter transitivity	a bigger current means, for bulbs, a bigger voltage	a bigger current means, for bulbs, a bigger luminosity
	a bigger voltage means, for bulbs, a bigger luminosity	
parameter inversion	a bigger current means, for bulbs, a bigger voltage	a bigger current means, for bulbs, a bigger voltage
quantifier negation	a bigger voltage means, for bulbs, a bigger luminosity	a smaller voltage means, for bulbs, a smaller luminosity
schematic inversion	bulb B is serial connected with bulb C	bulb C is serial connected with bulb B
schematic transitivity	the battery is connected in parallel with bulb A	the battery is connected in parallel with bulb chain BC
	bulb A is connected in parallel with bulb chain BC	

from this domain may be chosen by the student and dragged into the *points* or *conclusions* areas of the web page. We would like to point out that the choice of a good assertion domain D' is the key step in our endeavor of creating a good interactive learning task implementation for a given problem. Serious effort and consideration should be put into this step before doing any of the technical steps, since changes regarding the assertion domain usually effect all subsequent work. Clearly, the student has to describe the components of the schematic. In order to do this, the student may compose sentences by choosing an option from each of the columns given in table 1. The student also has to compare some of the electrical and physical parameters of the circuit elements by constructing sentences from options given in table 2. And last the student has to give information on how the parameters will influence each other regarding the bulbs. This can

Table 5: Initial set of correct assertions for our implementation of problem Q.

bulb A is connected in parallel with bulb chain BC
the battery is connected in parallel with bulb A
bulb B is serial connected with bulb C
the resistance of bulb A is as big as the resistance of bulb B
the resistance of bulb A is as big as the resistance of bulb C
the resistance of bulb chain BC is bigger than the resistance of bulb C
the voltage of bulb chain BC is bigger than the voltage of bulb B
a bigger voltage means, for bulbs, a bigger current
a bigger voltage means, for bulbs, a bigger input power
a bigger input power means, for bulbs, a bigger luminosity

be done by composing sentences from table 3. These three sentence templates constitute the assertion domain D', which has 2025 elements – sentences[4] which the student may use to complete the task.

After we have chosen the assertion domain for our implementation we have to think about the relations between the assertions and come up with an appropriate set R of valid inference rules. Since giving all the inference rules $I \in R$ in detail is a technical and tiresome task that does not provide deeper insights, we will only sketch the inference rules of our implementation here by sparing the technicalities and giving an example for each rule in table 4 instead.

Further we consider all correct assertions regarding the schematic, the fact that the voltage of the bulb chain BC is bigger than the voltage of each of the bulbs B and C, and the relations between the parameters to be obvious for our problem and hence do not demand reasons for them.

Having fixed the assertion domain D' and the set of inference rules R we need to give a set of assertions $A_0 \subseteq D$ such that (A_0, R) is a D'-base. In table 5 we list a set of assertions sufficient to determine whether any assertion $a \in D'$ from the assertion domain is correct.

4 CONCLUSIONS AND FURTHER WORK

In this paper we showed that scientific reasoning is an important skill that can be trained by appropriately designed interactive learning tasks. We elaborated a profound model that can be used to generate interactive web-based learning platforms that may provide feedback and tutor learners in order to improve their reasoning skills across different tasks and domains. We presented a sample implementation using a general framework. As part of future work this implementation framework may be used to create further computer-based interactive learning tasks, on which highly needed further empirical studies on training scientific reasoning may be based.

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[4] Notice that there are different sentences that essentially carry the same information, but since we allow for distinct solutions anyway, there is no need to enforce a normalized way of generating sentences from underlying information.

Self-consistent Peer Ranking for Assessing Student Work
Dealing with Large Populations

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Keywords: Large Scale Assessment, Peer Reviewing, Ranking Algorithm.

Abstract: Assessing large populations of students puts a serious burden on teaching staff capacity. For open-format assignments, automation of the reviewing process can offer only limited support. Peer ranking is a partial solution to the problem, with the added benefit that students' critical reading skills are developed. We see two remaining problems, however: (1) for students, it is a major challenge to assign marks on an absolute scale, and (2) students' competence in reviewing may vary significantly—so not all peer reviews should have a similar weight in the process. To remedy these shortcomings, we suggest an approach to peer ranking, inspired by Jon Kleinberg's HITS-algorithm, where both the students' assignment results and the quality of their double anonymous peer reviews are algorithmically ranked. Based on preliminary model calculations, we estimate that this strategy may reduce the required effort for reviewing open-format assignments approximately by a factor of ten. A first large-scale pilot with this method will take place in undergraduate courses at Eindhoven University of Technology, spring 2013. Since this involves about 900 students, automated support is a must. We describe the peer reviewing facilities that were introduced in our web-based education support system named peach[3].

1 MOTIVATION AND PROBLEM DEFINITION

Assessing large populations of students puts a serious burden on teaching staff capacity. This is even more so if strict deadlines need to be observed with respect to providing feedback to students. In a practical scenario, set at Eindhoven University of Technology in early 2013, some 900 students will be submitting elaborations of homework assignments, each corresponding to about two A4 pages of text, in a weekly rhythm, where marks need to be provided no later than two weeks after submission, and no more than two staff members are available for reviewing.

If reviewing a single work is estimated to take 20 minutes, completing the entire correction takes 300 person hours, or 150 hours per individual teacher. Although one week contains $24 \times 7 = 168$ hours, it is obvious that straightforward reviewing is no option.

Peer reviewing, i.e., students reviewing each other's work using a protocol that ensures anonymity, seems a plausible first option (Sadler and Good, 2006; Lu and Bol, 2007). A naive scheme, however, where students give marks to their peers, suffers from two obvious drawbacks:

1. Unless the assignments admit only a single correct answer, there is subjectivity involved in marking. In the current casus, the assignments are deliberately open ended. They contain questions of the form 'give an example for X', 'give some arguments in favor of, and some arguments against Y', or 'what is your substantiated opinion regarding Z'. Although a student can be expected to form a global opinion ('this is quite good'), we ask too much if this opinion should be made quantitative, say, on a 10-point scale.
2. More importantly, not all students can be expected to be equally competent reviewers. This problem could be mitigated by having every work reviewed by sufficiently many students, so that non-systematic errors can be expected to average out. This will not work in practice, however, since it is unrealistic to have students review more than, say, five works each.

Problem 1 is partially solved by having students merely *rank* works, that is, to put the (say) five works they review in order of quality, rather than to give absolute marks. From the methodology of social sciences (Mellenbergh, 2011), it is known that comparative ranking is generally easier than absolute ranking. We use the term “peer ranking” (following (Allain et al., 2006)) for comparative ranking in the context of peer review.

Peer ranking, however, does not completely solve Problem 1: as part of the assessment process, our students need an absolute marking.

The research question of this paper, combining Problems 1 and 2, is now stated as:

> ‘How can peer ranking be used, taking differences in students’ reviewing competences into account, in order to obtain absolute marks in assessments?’

For peer ranking that accounts for differences in reviewing competences among peers, we coin the term ‘self-consistent peer ranking’.

In Section 2, we formally define self-consistent peer ranking and an approach to it, loosely based on Jon Kleinberg’s HITS algorithm (Kleinberg, 1999). Some implementation details are described in Section 3. Prior to the actual implementation in a real-life setting, we want to gain some feeling for the merits of the approach. Therefore, we performed a model study; this is discussed in Section 4. Section 6 lists a number of possible variations of the method, Section 5 discusses the conditions for application of the algorithm in an educational context, and Section 7 discusses the web-based support facility `peach`[3]. Finally, in Section 8 we summarize our conclusions and indicate directions of future work.

2 PROPOSED APPROACH

The problem of ranking the quality of submitted works, based on judgments by reviewers with unknown and varying reviewing competence, somewhat resembles the problem that Google is solving by means of *page ranking*:

- a web page is *good* if many web pages link to it;
- not every link should contribute equally to the ‘goodness’ of a webpage;
- a link from a *good* webpage should contribute more;
- this gives a cyclic definition of what constitutes ‘good’ for web pages.

In the case of peer reviewing, the reasoning goes:

- a student’s work is *good* if peers have a high esteem of it;
- not every peer’s opinion should contribute equally to the ‘goodness’ of a work;
- the opinion of a *competent* peer should contribute more;
- this gives a cyclic definition of what constitutes ‘good’ (for works) and ‘competent’ (for peers).

The definitions for the goodness of a work and the competence of a peer can now be given formally.

Students have a *reviewing competence*, called c_i for student number i, $i = 1 \ldots N$. Competences are initially unknown.

Works have a *quality* (‘goodness’), called q_j for work number j, $j = 1 \ldots N$. Note that a q_j is not necessarily a final grade; that is, once we have an estimate for q_j, we still have the problem of converting it into a grade. Qualities are initially unknown. Review competence and quality of work are assumed to be independent variables.

An assessment where student i reviews work j produces an *indicator*, called a_{ij}. A larger a_{ij} value means that student i rates work j as better. The indicator a_{ij} gives information both about student i and work j. Again, this is not necessarily a grade. When a collection of a_{ij} is known, the challenge is to recover the c_i and the q_j.

For a first, naïve approach, we treat c_i and q_j symmetrically; we scale them between -1 and 1; we assume a full set of a_{ij} (that is, every student has reviewed every work), and we prepare the a_{ij} so that they are also scaled between -1 and 1. The values c_i, q_j, and a_{ij} are called *self-consistent*, when (a) the q_j are the weighted averages of the a_{ij}, where the c_i are the weight factors, i.e. $q_j = \sum_i a_{ij} c_i$, and (ii) similarly with the roles of c_i and q_j reversed, i.e., $c_i = \sum_j a_{ij} q_j$. The following algorithm, if it converges, produces a set of c_i and q_j that are self-consistent for given a_{ij}.

1. Initialize all c_i to random values between -1 and $+1$.
2. Calculate first estimate $\forall_j : q_j^0 = \sum_i a_{ij} c_i^0$.
3. Update $\forall_i : c_i^{n+1} = \sum_j a_{ij} q_j^n$.
4. Update $\forall_j : q_j^{n+1} = \sum_i a_{ij} c_i^{n+1}$.
5. Renormalize c_i and q_j to keep them between -1 and $+1$.
6. Repeat steps 3 through 5 until convergence, that is, $c_i^n \approx \sum_j a_{ij} q_j^n$; and $q_j^n \approx \sum_i a_{ij} c_i^n$.

This algorithm is in fact a so-called *power iteration* (Golub and Van Loan, 1996). Power iteration converges under weak conditions. Indeed, in case of convergence, $q = AA^T q$ holds, where q is a vector of q_j, and matrix A holds all a_{ij}. We see that q is an eigenvector of the positive-definite AA^T; the repeated scaling ensures that the largest eigenvalue is 1, and power iteration is a well-known stable route to find the eigensystem with the largest eigenvalue for positive-definite matrices.

The above algorithm has the same structure as Jon Kleinberg's HITS algorithm (Kleinberg, 1999), used for self-consistent ranking of scientific citations. In the next section, we examine the modifications and additions needed to make the algorithm work for self-consistent peer ranking.

3 IMPLEMENTATION DETAILS

To apply the algorithm from the previous section to reviewing students' works, we have to resolve three issues.

i. If students' reviewing comprises *ranking* instead of *marking* their peers' works, we have to *construct a numeric value* for a_{ij} for every pair (student i, work j) from all orderings on the collection of works as found by all students;

ii. Since students will review and rank no more than, say, five works each, the majority of a_{ij} is unknown. If an unknown a_{ij} is represented by 0 (encoding a neutral judgment for work j by student i), the matrix A is sparse. We must *cope with the sparseness* of A;

iii. We demand that, eventually, students receive marks for their works on some given scale, say 0 through 10. The q_j only carry information in their ordering; hence, we have to *convert ranks to absolute marks.*

The resolution of these three issues is closely related. We start with item iii, then i, and finally item ii.

3.1 From Ordered q_i to Marks

After completion of the algorithm, we re-order the q_j so that they are monotonically increasing in j. Now that we have obtained the vector q, we know the order of the quality of the works. This means that the eventual marks should be such that the work $j = 1$ should receive the lowest mark, and the work with $j = N$ receives the highest mark. The marks of the other works could be obtained, for instance, by linear interpolation between these two. The mark m_k for work k then is given by

$$m_k = m_1 + (m_N - m_1)(k-1)/(N-1) \qquad (1)$$

So, with merely correcting two works, we can assign marks to all works.

To obtain a more reliable set of marks, however, we may prefer to have a few more works corrected and marked by teaching staff. In case more works are marked by hand, the interpolation could be more advanced: with four hand-corrected works, we might choose the numbers 1, $N/3$, $2N/3$, N and use a piecewise linear function or a spline in k for the interpolation instead of (1).

3.2 From Ranking Results to a_{ij} Values

Students each rank a small collection of works. The result of ranking by student i is equivalent to a set of relations, $a_{ij_1} < a_{ij_2}$ for j_1 and j_2 in the set of indices of works, reviewed by this student. We may optionally allow ex aequo ranking, that is $a_{ij_1} = a_{ij_2}$ for some maximum number of pairs (j_1, j_2). Ranking information can be encoded in an anti-symmetric $N \times N$ matrix, say S_i, where $+1$ occurs in entry (j_1, j_2) when, according to student i, $a_{ij_1} < a_{ij_2;}$, and -1 occurs in entry (j_2, j_1). All other entries are 0.

For example, if student i ranked $a_{ij_3} < a_{ij_1} < a_{ij_2}$, then we will have

$$S_i \quad = \quad \begin{array}{c|cccc} & j_1 & j_2 & j_3 & \ldots \\ \hline j_1 & 0 & +1 & -1 & 0 \\ j_2 & -1 & 0 & -1 & 0 \\ j_3 & +1 & +1 & 0 & 0 \end{array} \qquad (2)$$

Next, all matrices S_i need to be aggregated to obtain the matrix A for the algorithm.

This aggregation is not trivial. For instance, the S_i need not all be mutually consistent. That is, an entry (j_1, j_2) may contain $+1$ in one of the S_i, whereas it is -1 in another $S_{i'}$. Now, prior to running the algorithm, the weights c_i are unknown. Still, it seems that the c_i are necessary to resolve conflicts due to inconsistencies. Therefore, for full self-consistency, the construction of A should take place simultaneous with obtaining c and q.

Although we plan to derive a fully self-consistent aggregation algorithm to obtain A from the matrices S_i in the future, we intend to run first trials with a simple approximation to this scheme. This approximation amounts to setting $a_{ij_1} = -1$ and $a_{ij_2} = +1$ for respectively the lowest and highest ranking works j_1 and j_2, according to student i, and to give the other works a_{ij} values that linearly interpolate these values. So, for five reviewed works per student, the a_{ij} are set to the sequence $-1, -0.5, 0, 0.5, 1$, *irrespective of any rank assignments by other students to these works.*[1] Constructing the a_{ij} from the initial ranking inputs in this way is obviously ad-hoc, and we will use it for a first trial only to see if the approach is promising.

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[1] When we admit ex aequo ranking, one or more of the values may be left out of the sequence $-1, -0.5, 0, 0.5, 1$.

3.3 Sparse *A*

Convergence of the algorithm can be proven for full rank matrix A. Due to sparseness, however, A is highly rank deficient. Fortunately, power iteration is relatively robust. This means that, as long as a minimum percentage of a_{ij} is known, the algorithm still can approximately recover c, and, more importantly, q from A. There are two considerations, however, that we need to take into account.

- Obviously, the fraction of non-empty entries in A cannot be arbitrarily low. Therefore, given that each student reviews five works, the total population of students (to be called 'cluster') in one peer-ranking trial cannot be too high. In order to estimate the size of the largest allowable cluster, we perform a model study, described in the next section.
- With increasing cluster size, the convergence of our algorithm becomes increasingly problematic. 'Problematic convergence' implies the following.
  - We need more iterations (perhaps infinitely many) until convergence. This is no fundamental issue: it is easy to detect convergence; by admitting a maximal number of iterations, we can conclude if convergence fails.
  - With full rank, the solution of the power iteration algorithm is unique. This can no longer be proven for rank deficient A. This again is no fundamental issue, however: when we run the iteration several times with different starting conditions, we can easily verify if converged solutions are sufficiently close.[2]
  - If A gets increasingly rank deficient, the obtained vector q will contain increasingly more noise. This means that the *accuracy* of the algorithm decreases, where the accuracy is defined as the extent to which the found order of the works matches with the order as it would be found with hand-correction. The match between the hand-corrected order and the order found by the algorithm can be empirically assessed by doing a hand correction of the entire cluster. Small mismatches—that is, mismatches where the rank position of any q_j does not differ too much from a rank position as would be found with hand correction—can be partially compensated for by doing a larger fraction of hand corrections—to the extreme where all works are corrected by hand, and there is no added value of peer ranking. We plan to find the optimal cluster size, such that the accuracy of the algorithm is sufficient, by means of empirical assessment prior to full-scale implementation of the algorithm.

4 MODEL STUDY

To get a first, global, idea of attainable maximal cluster size, and hence the maximal efficiency improvement that can be attained by self-consistent peer ranking, we perform a model study. In this model, we postulated a relation between the c_i (student's reviewing competence) and the a_{ij} (the scores, attributed to works j by student i) as follows.

- A student with higher c_i contributes values for a_{ij} that are closer to the true q_j. By the 'true q_j' we mean the q_j that would result if a teacher would have reviewed work j.
- A student with lower c_i inputs values for a_{ij} that are closer to a uniform random number between -1 and $+1$. That is, failing competence is modeled as an unbiased noise term.

Next, to test the algorithm, we set up a collection of size N of works, every work with a *known* quality q_j, and a collection of size N of students, every student with a *known* reviewing competence c_i. Cluster size N will be varied to see what cluster sizes give acceptable accuracy, where the number of reviewed works per student is kept fixed to five. Known qualities and reviewing competences are taken randomly between -1 and $+1$. The known c and q are called c_{known}, q_{known}, respectively.

With c_{known} and q_{known}, the matrix a_{ij} is computed as follows. For every i, five random j's are selected such that every work j is 'reviewed' by exactly five different students i. The scores a_{ij} are calculated as

$$a_{ij} = \frac{q_{\text{known}\,j}(1 + c_{\text{known}\,i}) + \mathcal{R}(1 - c_{\text{known}\,i})}{2}, \quad (3)$$

where $\mathcal{R} = \text{rand}(-1, 1)$ is a uniformly distributed random number between -1 and $+1$. All other a_{ij} are set to 0.

With matrix A set up in this way, the algorithm is run, and, if convergent, the resulting q and c are plotted against q_{known} and c_{known}. For ideal reconstruction, the graph should be monotonically increasing. The precise shape is determined by the normalization

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[2] There is one curious subtlety. If q is a solution to $q = AA^T q$, then so is $-q$. Since the elements of q are scaled between -1 and 1, we cannot distinguish q and $-q$ beforehand. If the teacher reviews both extreme works (that is, after renumbering, the works with $j = 1$ and $j = N$), however, it should be immediately clear which of the two is the best and which is the worst. This unambiguously fixes the sign of q.

used. In our case, the normalization is a Euclidean distance norm, resulting in a roughly sigmoid shape for the graph.

Experiments reproduce the predicted behavior, where increasing sparseness in A causes increasing deviations from purely monotonic. If we find 5% deviations acceptable (that is, 5% of the works receive an out-of-order q_j), the matrix A can be as sparse as 10%. In other words, for a cluster size as large as 50, with five reviews per work, the algorithm is capable to find an approximation to the correct order with no more than 5% errors.

It turns out, however, that the outcome of these trials is sensitive to the assumptions with respect to the precise form of (3). If we assume students are slightly more competent in reviewing, the performance of the algorithm is drastically better; if students are less competent, the performance is considerably worse—which is not too unexpected. Therefore, although these model trials suggest a cluster size of 50 with five reviewed works per student, we may want to be a bit more conservative when we actually implement the scenario for the first time.

5 DISCUSSION

An algorithm for calculating students' reviewing competence and the quality of students' work may be a necessary ingredient of peer reviewing, but it is definitely not sufficient. In (van Zundert, 2012), educational considerations regarding peer reviewing are studied. In this section, we list a number of assumptions that should hold for an algorithm like the present one to be trustworthy.

- Peer groups should be unbiased and uncorrelated so that every assessment can be seen as an independent measurement of each student's performance. Careful randomization helps to remove correlations; bias is more subtle to deal with, though. For instance, in case of misconceptions, shared by a majority of the students ('homework is boring'), correct answers (such as 'homework is exciting') may score systematically low, and the algorithm has no means to detect this error. It will manifest itself in that the order, calculated by the algorithm, consistently differs from the order obtained by staff. In preparing assignments, therefore, questions with likely answers that are objectively 'wrong', but that could result from collectively shared misconceptions, should be avoided. Rather, assignments should be such that students can base their scores on how much detail is provided, how elaborate an answer is, how clearly the answer has been written, how convincing the answer is, et cetera.
- Peer ranking should be applied to a series of assignments rather than a single assignment, so that statistical evidence can be used to assess the reliability of the final outcome. Statistical evidence could be, e.g., the standard deviation σ of the marks over a series of assignments in one term. If σ decreases as one over the square root of the number assignments, N, it may be the case that the outcome indeed measures students' performance during that term. In case σ does not decrease with increasing N when averaging over the series of assignments, the per-assignment scores apparently do not measure the actual performance level of a student, and the peer review gives no information about this level. There could be various reasons for such inconclusive outcomes: perhaps the assignments do not accurately measure students' performance levels, or students performance levels vary wildly over the term. From a methodological point, it would be good to include the σ's in the final marks.

6 POSSIBLE VARIATIONS

We briefly present three possible variations.

1. The algorithm calculates both c and q from scratch, using the matrix A as only input. We may expect, however, that the students' reviewing competence will not vary much over time. This suggests to bootstrap the algorithm with the results in the first week, and use the found c as a first estimate in the next week. We may even consider to use the running average of the c's over subsequent weeks, representing the intuition that we get increasingly more accurate estimates of the individual students' reviewing competence.
2. Teachers may consider to have one or more 'example elaborations' to be, unknowingly, reviewed by the students. Since works are reviewed anonymously, students will not know that they review a teacher's work instead of one of their peers. Assuming that teacher's works have insurmountable quality, the associated q_j must keep a constant value of 1 during the iterations. Therefore, they serve to further stabilize the algorithm.
3. Despite the efficiency improvement offered by the algorithm, reviewing still requires works to be assessed by teachers, which takes time. To reduce waiting time for students, feedback can be given in three tiers. The first tier is immediately after the

raw ranking: a student then can be informed about the ‘five relative rankings among four other works that this student’s work received. Although this carries no absolute information, the difference between ‘five times number one’ or ‘five times number five’ is probably significant. The second tier is immediately after running the algorithm: students then can get a percentile score (‘85% of your cluster has lower scores than you’). Only the third tier feedback, where a student receives an absolute mark, needs to wait until teachers correct the few representative works per cluster.

7 WEB-BASED SUPPORT: peach^3

At Eindhoven University of Technology, we use a web-based education support system peach^3, since 2001 (Scheffers and Verhoeff, 2012). Students submit their work for deadlined assignments to peach^3 through a web browser. peach^3 monitors the deadlines, stores submitted work, performs configurable automatic checks on the content, disseminates it to those involved in the course, and allows entering of manual feedback and grades. Recently, we added support for peer reviews, including peer ranking.

To carry out a peer review of an assignment Z, a new assignment is created that is designated as a peer review of Z. Students who submitted work for Z are allocated random works by other students within their cluster, in such a way that each work is reviewed by a configurable number of students (in this paper, we have used five as bundle size). They read anonymized versions of work under review in a browser, and provide review reports, grades, and/or a ranking with respect to each other, through a web GUI. All review results can then be exported, processed, and imported back into the system as grade. Afterwards, if so desired, students can see anonymized review reports, grades, and rankings of their work.

8 CONCLUSIONS, FUTURE WORK

We propose a strategy for reducing the amount of reviewing, to be done by teachers, for open-ended assignments. An algorithm, called *self-consistent peer ranking*, requires students in a cluster of peers to anonymously rank, say, five peer works. The differences between students’ ranking competence (the c_i in the algorithm) are estimated, and used to compute a weighted final rank score (the order of the q_j in the algorithm). Next, teachers review the highest and lowest ranking work (and perhaps few more for increased reliability) in a cluster, to establish the absolute marks; marks of works not reviewed by teachers are found by interpolation.

A preliminary model study suggests that clusters can contain some 40 to 50 students, which would indicate a factor of 8 to 10 reduction of manual correction work, if students rank five works each, while the amount of out-of-order errors of the algorithm is no more than 5%. A group of 1000 students would then be split into 20–25 clusters.

A first field trial will take place early 2013 at Eindhoven University of Technology, involving about one thousand students. This will involve our web-based education support system peach^3, that provides support for peer reviews and peer ranking. If the results are promising, we will fine tune the cluster size and other parameters in the algorithm to get the optimally achievable efficiency improvement. Also, we will develop the algorithm further so that the matrix A can be obtained from the individual ranking inputs without having to resort to the ad-hoc assignment of a range of numerical values to the a_{ij} for given i.

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Towards Evidence-aware Learning Design for the Integration of ePortfolios in Distributed Learning Environments

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Abstract: The benefits of using ePortfolios in widespread Distributed Learning Environments are hindered by two problems: students have difficulties in selecting which learning artifacts may demonstrate the acquisition of certain learning skills; and, both teachers and students have difficulties in collecting evidences produced by means of distributed and heterogeneous tools. This paper proposes a model aimed at enhancing the description of learning activities with information about the evidences they are expected to generate. This model is a first step towards the definition of an evidence-aware learning design process by means of which teachers make explicit pedagogical-informed decisions involving the generation and subsequent utilization of learning evidences. As a proof of concept, we apply this model in an authentic learning scenario, trying to alleviate the two aforementioned problems.

1 INTRODUCTION

Technology Enhanced Learning (TEL) is a research field that promotes the use of information technologies to better support learning. Following this approach, it is common to use VLEs (*Virtual Learning Environments*) (Dillenbourg, 2000) to orchestrate the involved activities by managing students and groups of them, as well as learning tools and resources. In addition to VLEs, teachers typically make use of external tools, specially Web 2.0 ones such as blogs or wikis, in their learning settings. Indeed, there are a number of approaches to integrate third-party tools in VLEs such as IMS LTI (IMS-LTI, 2012) or GLUE! (Alario-Hoyos et al., 2013). As a result, the term DLE (*Distributed Learning Environment*) (MacNeill and Kraan, 2010) is employed to refer to the technological setting composed of VLEs and external tools.

On the other hand, ePortfolios, may be understood as an organized compilation of selected work samples (evidences), which show the process and results of a learning path (Barberà-Gregori and Martín-Rojo, 2009). ePortfolios are gaining momentum, due to their benefits over the cognitive process of the students (Barrett, 2007b) (Buzzetto-More, 2010) (Reese and Levy, 2009).

By using ePortfolios, learners get a better understanding of their own learning progress and their level of accomplishment of the targeted competences, as well as increase their motivation for learning (Sweatguy and Buzzetto-More, 2007). At the same time, teachers may complement traditional summative evaluation with formative assessment and feedback on the on-going work, considering ePortfolios as both a *process* and a *product* (Barrett, 2011).

However, when putting together ePortfolios and technically heterogeneous DLEs, the assessment of individual students becomes specially difficult, due to learning evidence dispersion among the employed tools (Bubaš et al., 2011) (Barrett, 2007a). Teachers' workload increases when trying to gather those work samples. At the same time, students find it difficult to understand and choose the suitable pieces of work which allow showcasing the acquired competences (Buzzetto-More, 2010). These problems are exacerbated in group work due to the complexity of collaboration (Koschmann, 1996).

Hence, teachers should be helped to gather evidences, plan and carry out assessment; while students should be guided to exploit the advantages of ePortfolios in these environments (Barberà-Gregori, 2005). In order to reach this purpose, learning evidences need to be identified among all the artifacts generated by students in a learning situation. Also, learning evidences need to be linked to learning objectives, as to clearly state which work samples help reaching which goals.

This way, it seems important that teachers are asked to make explicit the aforementioned guidelines. Learning design (Conole, 2012) (Laurillard, 2012) has evolved during the last decade as the approach for helping educators to make their pedagogical decisions, as well as the use of educational technology, explicit and sharable. However, no attention has been paid so far, within the learning design community, to the inclusion of learning evidences (and their purpose) in the design of learning situations. Therefore, this paper proposes a so-called learning evidence-aware model that defines how a teacher might define learning evidences and how he might relate those evidences with the components of current learning designs.

This contribution is seen as a first, necessary step to build a solution aimed at avoiding the main drawbacks of integrating ePortfolios in DLEs. That is, in order to be able to exploit technology for the automation of evidence collection (and, therefore, mitigate the workload increase due to ePortfolios), teachers are required to explicitly identify those artifacts which will be considered learning evidences and the purposes and learning objectives they will serve to. At the same time, the link between learning evidences and objectives will be explicit, therefore helping students to exploit ePortfolios to build their digital identity, by showcasing what they have learned.

The structure of the document goes as follows. Section 2 explains the most important problems which students and teachers need to face, when using ePortfolios in DLEs. Section 3 presents a learning evidence integration model, which will enable tackling the aforementioned problems; and applies it to a DLE-based learning situation. Finally, conclusions and future work are given in Section 4.

2 ePortfolios AND DLEs

ePortfolios are known for their capability of documenting the learning process, being an ordered store of work samples, called *learning evidences*. In order to do so, evidences must go through the following processes: *collection*, *selection*, *reflection* and *presentation* (Barberà and Bautista, 2006).

That is, students need to take samples of their work, decide whether they are suitable to show the achievement of some learning objectives, self-evaluate their work on the selected samples and finally publish the contents of their portfolio so that the audience may understand how far they got in reaching a given competence.

By doing so, ePortfolios help students to become aware of their self-progress, increasing their understanding of what, why and how they learnt (Barrett, 2007b). This capability (providing a glance at the learning path) also enables the use of ePortfolios as assessment tools (Balaban et al., 2011).

Three main approaches may be followed in the use of ePortfolios (Barrett, 2011). On a first approach, ePortfolios may be seen as a way to centralize digital work samples. That is, the main purpose of this kind of portfolios is *storage*, paying special attention to evidence collection.

Secondly, the selection of evidences allows the use of ePortofolios as a *workspace*, focused on the ongoing learning situation. Students execute short-term reflection on the learning process, while teachers should provide feedback and formative assessment towards the aimed learning objectives.

Finally, students may present the level of achievement of certain competences by using the ePortfolios as a *showcase* of their final retrospective on what they learned, either after a given learning situation or across several ones.

This way, in order to exploit those benefits in distributed learning environments, some proposals appear, for the joint use of VLEs, web 2.0 and ePortfolio systems (Salinas et al., 2011) (Bubaš et al., 2011) (Hämäläinen et al., 2011).

However, even when a conceptual link is established among VLE, tools and ePortfolios, there is not a real connection among them, thus hindering the management of learning evidences. This means that, at the end of the learning situation, the work samples are scattered along the different tools or the VLE itself, difficulting their gathering and the teacher's tasks to provide assessment (either summative, formative of feedback). This problem gets more complicated in collaborative flows, including portfolios. The teachers' workload increases, while their confidence in portfolio benefits decreases (Balaban et al., 2011) (Sweat-guy and Buzzetto-More, 2007). Additionally, lack of consistency among different teachers for the same learning objectives may appear (Barberà-Gregori, 2005).

From the students' perspective, the main problem in evidence selection is their lack of experience in doing so. It may be difficult for them to identify which parts of their work better match the learning objectives (Barrett, 2007b) (Barberà-Gregori, 2005) (Buzzetto-More, 2010).

Taking all this into account, it seems reasonable for teachers to devote some time to decide which learning evidences are most interesting to fit the learning objectives they aim at. That is, they should be able to explicitly identify what to collect, what for and how that links to the learning objectives they defined (Venn, 2004).

This kind of decisions should be taken when designing the learning situation. At that point, the flow of activities to be executed is specified, where students and teachers play roles and use services and tools with the aim of accomplishing their learning goals (Conole, 2012) (Laurillard, 2012). Some research works criticize that current *Learning Design* (LD) approaches do not allow the specification of data flow among tools and activities (Palomino-Ramírez et al., 2007) (Prieto et al., 2011). To address this limitation, they propose workflow models for automating the flow of learning artifacts in a learning situation. However, their focus is mainly technological, leaving out assessment considerations, as well as the use of those artifacts for showcasing learning competences.

This paper, on the other hand, tries to go a little further, by providing meaning to those artifacts, highlighting the most relevant ones, and linking them to the learning goals. Gathering all this information in a structured manner is the first step towards automation of collection and management of learning evidences. This way, technology can help to reduce teacher workload in DLEs and to create better designs, as well as to tackle students' lack of experience in evidence selection.

3 LEARNING EVIDENCE AWARE DESIGN

Along the previous sections, the main difficulties in the adoption of ePortfolios in DLEs have been spotted.

The need of teachers taking learning evidences into account in the design phase is identified as a necessary step to provide technical aid to overcome those difficulties. In order to do so, LD authoring tools, such as *Collage* (Hernández-Leo, 2006) (Villasclaras-Fernández et al., 2009), may be used. Design tools offer certain possibilities to describe a learning situation, by using the model they implement as reference. However, none of those models explicitly talk about learning evidences, nor ePortfolios (Prieto et al., 2011) (Palomino-Ramírez et al., 2008).

Therefore, Section 3.1 proposes a design model to integrate learning evidences in the design of learning situations, while Section 3.2 instantiates a CSCL situation in which learning evidences play an important role. By doing so, the basis of an evidence-aware design process is set, which will allow overcoming the main problems in the integration of ePortfolios in DLEs. The aim of this process is to help teachers elaborate an evidence-aware design, by applying the proposed model.

3.1 Learning Evidence Integration Model

Figure 1 depicts the proposed integration model to include learning evidences in the design of learning situations.

Learning objectives are inherently linked to the **learning design** itself, which will contain some **learning activities**, leading to those goals. **Learning activities** are supported by different **tools** (either inside or out of the VLE), which produce work samples to evidence the student's progress.

There are several purposes an **evidence** may pursue (as detailed in Section 2). First, simple **storage** will allow later use and summative assessment. For example, the mind map at the end of a given activity may be evaluated by the teacher when the learning situation is over.

However, **learning evidences** may be also used along the enactment of the learning situation, in order to provide **feedback** on the student's learning path, either by the teacher or the students themselves.

Finally, it is important to indicate which **learning evidences** demonstrate which **learning objectives**, so that students may use this information to **showcase** the acquired competences.

By specifying all this information, a cyclic workflow is established. Learning evidences are the output product of given steps in the learning process, but may also become input resources in forthcoming learning and/or assessment activities; as shown in the example in Section 3.2.

3.2 Application Scenario

This section applies the evidence-aware learning design model described in Section 3 to a collaborative scenario, inspired in a course in the study plan for Telecommunications Engineering at the University of Valladolid (*Networks and Telematics Systems*, 3rd semester[1]). This course, among other topics, covers the analysis of network diagrams, and the use of network discovery and routing tools.

One of the learning situations in that course has the following learning objectives:

- LO01: Depict and read network diagrams.

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[1] http://www.tel.uva.es/docencia/asignaturas/descripcion.htm?controlador(titulacion)=Pcomun&controlador(asignatura)=A45016

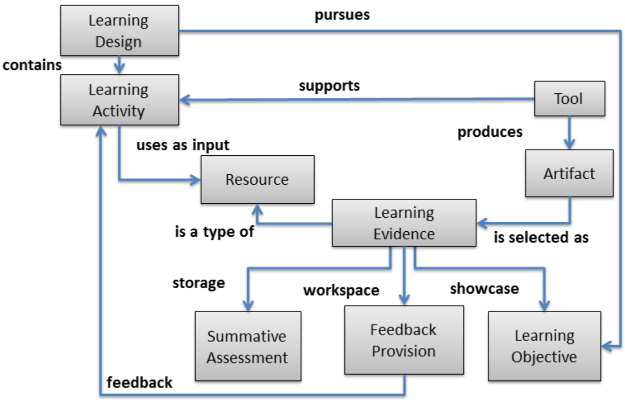

Figure 1: Learning Evidence Integration Model.

- LO02: Learn how to use network routing and diagnosis tools
- LO03: Understand that other's work is important to reach my objectives (positive interdependence)
- LO04: Learn how to use collaborative editing tools

Focusing on those aims, the teacher decides to use the pyramid collaborative pattern depicted in Figure 2 (Hernández-Leo, 2006). The leading thread along the learning situation will be held by the VLE Moodle[2], but different activities will make use of specific tools: Network Notepad[3], Google Docs [4].

Additionally, the teacher decides to exploit the main capabilities of ePortfolios, by setting up an instance of Mahara to be used as evidence meeting point, so that teachers and peers may provide feedback over the generated artifacts. At the same time, work samples may be shared across phases and students.

A schema of this learning situation is depicted in Table 1

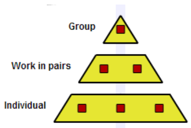

Figure 2: High-level overview of the learning situation.

Being an example of DLE, generated artifacts are scattered among tools, services and platforms. Counting all evidences (networks diagrams, test results and reports), the number of relevant artifacts goes up to almost two and a half times the number of students. That is, in a classroom of 40 people, the teacher ends up facing 90 artifacts.

Both teacher assessment and peer review imply an extra piece of work for authors of the artifacts, as they need to manually gather their results and place them in Mahara[5]. Also there is a lot of extra generated items (drafts, execution logs...), needed to get to the final product, whose link to learning objectives is not clear to students.

By following the design model in Section 3.1, as shown in Table 1, the teacher completes the traditionally provided information (activity description, tool, ...), by explicitly picking up some artifacts (e.g. [LE01]) to be considered as evidences. Those work samples should go into the ePortfolio management system (Mahara in the example), easing feedback provision and avoiding evidence dispersion.

Also, evidences may be identified as the output of an activity, but also as input resources to some learning and/or assessment activities (e.g. [LE02]). These pieces of information will be eventually used to indicate an automation engine where to find and where to place the necessary learning evidences to enact the provided design.

Finally, evidences are clearly related to learning objectives, which will help students understand what, how and why they learnt.

To sum up, using the evidence-aware learning model as reference is the first step to build a consistent solution for the integration of ePortfolios in DLE. Next lines of work are identified in Section 4.

4 CONCLUSIONS

Along this document, the challenges of using ePortfolios in DLEs have been identified. First, students lack of experience in evidence selection, which hinders the task of linking work samples to learning ob-

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[2] http://moodle.org/

[3] http://www.networknotepad.com/

[4] http://docs.google.com/

[5] http://mahara.org/

Table 1: Evidence-aware design of a pyramid (Learning Evidences in bold font).

Phase	**Learning Activity**	**Tool**	**Resource**	**Artifact**	**Learning Objective**
Individual	Depict first draft of the ETSIT Network, theoretical base	Network Notepad	-	**Network Diagram [LE01]**	**[LO01]**
Work in pairs	Review the first network draft by my colleague	Mahara	**[LE01]**	Feedback [FB01]	-
	Consume feedback	Mahara	[FB01]	-	-
	Depict second draft of the ETSIT Network, empiric base	email	-	Collaboration mails between students	-
		ping, tracert, lookup, whois	-	Execution logs	-
		Network Notepad	-	**Network diagram [LE02]**	**[LO01], [LO02], [LO03]**
	Answer test	Google Form	-	**Questionnaire Response [LE03]**	-
	^{Teacher}Assess questionnaire response	Google Form	**[LE03]**	-	-
Groups	Review the network diagram generated by my colleagues	Mahara	**[LE02]**	Feedback [FB02]	-
	Consume feedback	Mahara	[FB02]	-	-
	Create report, include network diagram, support decisions on theory	email	-	Collaboration mails between students	-
		chat	-	Collaboration conversations among students	-
		ping, tracert, lookup, whois	-	Execution logs	-
		Network Notepad	-	Network diagram	-
		Google Docs	-	**Written report [LE04]**	**[LO01],[LO02], [LO03],[LO04]**
	^{Teacher}Assess written report	Google Docs	**[LE04]**	-	-

jectives. On the other hand, assessment of students becomes harder when using ePortfolios in distributed and heterogeneous environments, due to learning evidence dispersion. Teachers are exposed to a larger workload which decreases confidence in the benefits of ePortfolios as assessment tools.

This paper supports the idea of making pedagogical decisions explicit on what evidences may be used to prove the achievement of some learning objectives and at which point within the learning situation they must be taken. Teachers use learning design to untangle their ideas to organize learning situations. However, current learning design approaches do not consider the use of learning evidences. To overcome this limitation, a model for the integration of learning evidences has been presented in Section 3. This model has been used on a sample scenario, to highlight the use of evidences within a collaborative learning pattern.

This way, by considering learning evidences in the design phase, technology can be used to alleviate the workload of teachers, as well as guide students to understand which work samples relate to which competences.

However, evidence collection remains a big problem in the chosen distributed and technically heterogeneous scenario, composed of VLE, external tools and ePortfolio management systems. The development of technical solutions for evidence gathering in DLEs based on this model is the following step in this research work. Additionally, the definition of a learning design process also based on the proposed model is aimed, so as to influence teacher-oriented authoring tools presented along this paper.

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Balanced Scoring Method for Multiple-mark Questions

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Abstract: Advantages and disadvantages of a learning assessment based on multiple-choice questions (MCQs) are a long and widely discussed issue in the scientific community. However, in practice this type of questions is very popular due to the possibility of automatic evaluation and scoring. Consequently, an important research question is to exploiting the strengths and mitigate the weaknesses of MCQs. In this work we discuss one particularly important issue of MCQs, namely methods for scoring results in the case, when the MCQ has several correct alternatives (multiple-mark questions, MMQs). We propose a general approach and mathematical model to score MMQs, that aims at recognizing guessing while at the same time resulting in a balanced score. In our approach conventional MCQs are viewed as a particular case of multiple-mark questions, thus, the formulas can be applied to tests mixing MCQs and MMQs. The rational of our approach is that scoring should be based on the guessing level of the question. Our approach can be added as an option, or even as a replacement for manual penalization. We show that our scoring method outperforms existing methods and demonstrate that with synthetic and real experiments.

1 INTRODUCTION

Advantages and disadvantages of a learning assessment based on multiple-choice questions (MCQs) are a long and widely discussed issue in the scientific community. However, in practice this type of questions is very popular due to the possibility of automatic evaluation and scoring (Farthing et al., 1998). Consequently, an important research question is to exploit the strengths and mitigate the weaknesses of MCQs. Some systems (e.g. Moodle [1]) allow teachers to create MCQs with multiple correct options. This type of questions we will call multiple-mark questions (MMQs), to distinguish them from the conventional MCQs, where there is always only one correct option. Multiple-mark questions were already recommended by Cronbach (Cronbach, 1941). Other research (Ripkey and Case, 1996; Pomplun and Omar, 1997; Hohensinn and Kubinger, 2011) considers MMQs to be more reliable, when compare them with conventional MCQs. However, even though the advantages of MMQs are meanwhile widely accepted, up to our knowledge there are no balanced methods for scoring multiple-mark questions available to date.

One possible approach to score the MMQs is to use dichotomous scoring system. The dichotomous scoring awards the constant amount of points, when the question is answered correctly and zero points in a case of *any* mistake. However, the partial scoring is preferable to the dichotomous, especially in case of MMQs. (Ripkey and Case, 1996; Jiao et al., 2012; Bauer et al., 2011; Ben-Simon et al., 1997)

The second possible approach is to use the methods, developed for scoring the multiple true-false questions (MTFs). However, despite the possibility to convert the MMQs into MTFs, the studies (Cronbach, 1941; Dressel and Schmid, 1953) discuss the differences between two formats and show disadvantages of MTF questions compared to MMQs. In the paper we show that the differences prevent the applying methods developed for the MTFs to the MMQs scoring.

Another possible approach is to use the penalties, similarly to the paper-based assessment where the teacher can analyze the student answers and decide how much points she deserves. The method was proposed by Serlin (Serlin and Kaiser, 1978). For example, in Moodle a teacher has to determine what penalty applies for choosing each distractor. However, this work is an additional, unpopular burden for teachers, since not required in paper-based tests. Instead of asking the teacher, some systems calculate the penalties automatically. However, computer-based assessment opens additional possibilities to guess, for example choosing all options. Often the scoring algorithms do

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[1] https://moodle.org/

not take into account such ways of guessing.

Consequently, we are facing the challenge to find a scoring method, that is able to recognize and properly penalize guessing. Previously proposed algorithms suffer from imbalance and skewness as we show in 2.

The task to find the scoring method can be divided into two steps: to find a method to determine points for the correctly marked options(1) and to find a method to determine the penalty for the incorrectly marked options(2). For the first part a reasonable approach was proposed by Ripkey (Ripkey and Case, 1996). Thus our research aims to provide a method for the second part (determining penalties). We propose a general approach and a mathematical model, that takes into account the most common ways of guessing and behaves balanced at the same time.

Our concept is based on the assumption, that scoring can be based on the *guessing level* of the question. By guessing level we mean here (in partial scoring) the probability to obtain more than zero points. Each question is associated with a difficulty to guess a (partially) correct answer. To accommodate the difficulty level of guessing in the scoring method, we propose to determine the penalty only when a student marks more options, than the actual number of correct ones. We argue that our approach can be added as an option, or even as a replacement of manual designation of penalties. We claim that our algorithm behaves better, than existing ones and prove that with both synthetic and real experiments.

The paper is structured as follows: first, we discuss existing algorithms for scoring MMQs, then we describe our approach on conceptual and mathematical levels and finally we show and discuss the results of synthetic and real-life experiments.

2 RELATED WORK

There are several existing platforms, that use multiple-mark type of questions as well as several approaches to score them. We collected such approaches to describe, discuss and compare them. Existing approaches for scoring the multiple-mark questions implement four base concepts. In the section we describe the basic ideas, advantages and disadvantages of these concepts.

2.1 Dichotomous Scoring

This method is often used in paper-based quizzes, where the good quality of quizzes allows teacher to be more strict when score the results. As the aim of e-based quizzes is not only to score the results, but to catch the gaps of knowledge, the scoring of partially correct responses shows the actual knowledge of the student better. Also, dichotomous scoring does not show the accurate progress of the student. However, when dealing with multiple-mark questions dichotomous scoring almost excludes the possibility of guessing, that is why we use it as a standard of reference when evaluating our approach with real users.

2.2 Morgan Algorithm

One of the historically first methods for scoring the MMQs was described in the 1979 by Morgan (Morgan, 1979). For our experiments we use the improved algorithm, in accordance to which the scores are determined by the following algorithm:

1. for each option chosen which the setter also considers correct, the student scores $+(p_{max}/n)$, where n is a number of correct options
2. for each option chosen which the setter considers to be incorrect, the student scores $-(p_{max}/k)$, where k is a number of distractors.
3. for each option not chosen no score, positive or negative, is recorded regardless of whether the setter considers the response to be correct or incorrect.

However, the experiments show a large dependence between number of options (correct and incorrect) and amount of penalty, that indicates the skewness of the method (see 4.1).

2.3 MTF Scoring

Multiple-mark questions can be scored with the approaches developed for multiple true-false items. Tsai (Tsai and Suen, 1993) evaluated six different implementations of the approach. Later his findings were confirmed by Itten (Itten and Krebs, 1997). Although both researches found partial crediting to be superior to dichotomous scoring in a case of MTFs, they do not consider any of the algorithms to be preferable. This fact allows us to use the most base of them for our experiments.

MTF scoring algorithms imply that any item has n options and a fully correct response is awarded with full amount of points p_{max}. If the user did not mark a correct option or marked a distractor, she is deducted with the penalty $s = p_{max}/n$ points. Thus a student receives points for not-choosing a distractor as well as for choosing a correct option. This point does not fit perfect to multiple-mark questions because of the differences between two types (Pomplun and Omar, 1997; Cronbach, 1941; Frisbie, 1992). Our experiments (see 4.1) confirm the studies and show the skewness of the concept when deal with MMQs.

2.4 Ripkey Algorithm

Ripkey (Ripkey and Case, 1996) suggested a simple partial crediting algorithm, that we named by the author. In the approach a fraction of one point depending on the total number of correct options is awarded for each correct option identified. The approach assumes no point deduction for wrong choices, but items with more options chosen than allowed are awarded zero points. The Ripkey's research showed promising results in a real-life evaluation. However, later researches (e.g. Bauer (Bauer et al., 2011)) notice the limitations of the Ripkey's study. The main issue in the Ripkey algorithm is the not well-balanced penalty. We aim to improve the Ripkey's algorithm by adding the mathematical approach for evaluating the size of penalty.

3 BALANCED SCORING METHOD FOR MMQs

3.1 Concepts

As shown above, existing approaches do not solve the problem of scoring MMQs perfectly. Our concept is based on the assumption, that scoring can be based on the guessing level of the question. Thus, when a student marks all possible options, she increases the guessing level up to 1. In this case the student should obtain either the full amount of points (if all the options are considered to be correct by the teacher), or zero, if the question has at least one distractor. However, if a student did not mark any option, the score should be always zero, as we assume that all the questions have at least one correct option. Thus, the task is to find the correctness percentage of the response and decrease it with a penalty, if the guessing level was artificially increased by marking too many options.

Questions have the native level of guessing, and we propose to deduct the penalty only if after the student's response the guessing level increases. In other words, we determine the penalty only when a student marks more options, than the number of correct ones.

3.2 Mathematical Model

In this section we present the mathematical model, that can be used for its implementation.

3.2.1 Scoring the Basic Points

To score the basic points we use the approach, described by Ripkey. Below we present it mathematically in accordance with the following designations:

- $d \in \mathbb{R}, d \in (1..d_{max}]$ – difficulty of the current question, for our experiments we set $d_{max} = 5$
- $C \subseteq A$ – set of the *correct* options c_i for the current question, where A – set of the options a_j for the current question,
- $c_{max} = |C|, c_{max} \in \mathbb{N}$ – number of *correct* options for the current question
- C_{ch} – set of the *correctly checked* options
- $c_{ch} = |C_{ch}|, c_{ch} \in \mathbb{N}, c_{ch} \in [0, c_{max}]$ – number of *correctly checked* options for the current question
- $p_{max} = f(d) = d * K_{points}$ – maximal possible points for the current question, in our system we set $K_{points} = 1$
- p_c – points for the correctly checked option c. As we assume all the correct options have the equal weight, $\forall c \in C_{ch} | p_c = \frac{p_{max}}{c_{max}}$
- $p \in \mathbb{R} \wedge p \in [0, p_{max}]$ – the basic points for the current question, $p = \sum_{c \in C_{ch}} p_c \Rightarrow p = \sum_{c \in C_{ch}} \frac{p_{max}}{c_{max}} = \frac{p_{max}}{c_{max}} * c_{ch} = p_c * c_{ch}$

3.2.2 Scoring of the Penalty

Below we present our approach for scoring the penalty. We use the following designations:

- $a_{max} \in \mathbb{N}, a_{max} = |A|$ – number of options $a \in A$
- $Ch \subseteq A$ – set of *checked* options
- $ch = |Ch|, ch \in \mathbb{N}, ch \in [0, a_{max}]$ – number of checked options for the current question
- $b \in \mathbb{R}, b \in [0,1]$ – basic level of guessing for the current question, $b = \frac{c_{max}}{a_{max}}$
- $n \in \mathbb{R}, n \in [b,1]$ – measure, that shows the possibility, that user tries to guess the correct response by choosing too much options; we do not evaluate it in the cases, when $n <= b$,$n = \frac{ch}{a_{max}}$
- s – penalty for the guessing, $s = n - b \Rightarrow s \in [0, 1 - b]$
- $s_k \in [0, p_{max}]$ – the penalty, mapped to the maximal possible points.

A mapping function will be: $f : s_k \to s$
Given, $s_k \in [0, p_{max}]$ and $s \in [0, 1-b]$, then
$f : s_k \to s = f : [0, 1-b] \to [0, p_{max}] \Rightarrow s_k = f(s) = s * \frac{p_{max}}{1-b} = (n-b) * \frac{p_{max}}{1-b}$

The absolute score for the question is trivially determined as $T = f(p, s_k) = p - s_k$

4 EVALUATION

4.1 Synthetic Experiments

In the subsection we describe our experiments with synthetic data and compare the behavior of different methods. We consider all the questions to have the difficulty $d = 1$, then the maximal possible points $p_{max} = 1$ as well.

Table 1: Comparison of the proposed approach with other existing approaches.

Dich.	MTF	Morgan	Ripkey	Balanced
0	0.4	0	0	0

Example 1 (Case: 5 options, 2 correct, 5 marked)**.** *In the case the student chose all the options and should obtain zero points. However, we see that MTF method does not recognize this type of guessing and considers the questions to be answered partially correct, awarding the points for two correct options, that were marked.*

Table 2: Comparison of the proposed approach with other existing approaches.

Dich.	MTF	Morgan	Ripkey	Balanced
0	0.6	0	0	0

Example 2 (Case: 5 options, 2 correct, 0 marked)**.** *The situation is opposite to the previous: in the case the student chose none of the options. As we assume that question must have at least one correct option, in case of not choosing any options a student also should obtain zero points. However, we see that MTF method awards the points for three distractors, that were not marked. Although the situation is absurd, we faced it within real learning platforms, for example within several on-line courses of the Stanford University* [2].

Two examples below are trivial and the problem could be solved by adding the rules. However, the MTF scoring also suffers from skewness, when applied to MMQs, as it is shown below.

Table 3: Comparison of the proposed approach with other existing approaches.

Dich.	MTF	Morgan	Ripkey	Balanced
0	0.83	0.5	0.5	0.5

Example 3 (Case: 6 options, 2 correct, 1 correct marked)**.** *This case proves, that the MTF method has a dependency from a number of correct and incorrect options. Thus, in a case of 6 options two of which are correct, a student is awarded 0.833 points for choosing only one correct option. In a case of 5 options two of which are correct, she would be awarded 0.80 points for the same. Moreover, if she choose only one incorrect option in a case of 6 alternatives, she obtains 0.5 points; in a case of 5 options she will be awarded 0.4 for the same.*

Thus, our experiments prove, that multiple-mark questions can not be scored properly with the algorithms, developed for multiple true-false items. However, the MTF scoring is the only existing approach of partial scoring that can be used in a case, when a question does not have any correct options.

Table 4: Comparison of the proposed approach with other existing approaches.

Dich.	MTF	Morgan	Ripkey	Balanced
0	0.5	0	0.5	0.5

Example 4 (Case: 4 options, 2 correct, 1 correct and 1 incorrect marked)**.** *This case illustrates the issues of using the Morgan algorithm. The Morgan algorithm deducts penalties for choosing the incorrect option, as well as the proposed approach. However, in that case we are facing the situation, that penalty has the same size, as the basic points, and the student is awarded zero. We consider the penalty to be needlessly high, especially because the penalty depends on the number of incorrect options. Thus, if the question has 3 incorrect options, choosing one of them would be fined on 0.33, and in case of 2 incorrect options, the penalty is 0.5. After recognizing behavior of the algorithm, students will mark only the options, they are sure in, because choosing an incorrect one may cost them a full amount of points, they collected with correct options.*

The next two examples show mainly the differences between the proposed approach and Ripkey algorithm. Namely, we show the situations, when Ripkey algorithm awards zero points, while we consider that it should award more.

Table 5: Comparison of the proposed approach with other existing approaches.

Dich.	MTF	Morgan	Ripkey	Balanced
0	0.75	0.5	0	0.5

Example 5 (Case: 4 options, 2 correct, 2 correct and 1 incorrect marked)**.** *In this case the student chose*

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[2] http://online.stanford.edu/courses

more options, than the number of correct ones, and according to the Ripkey, the answer should be awarded zero. Our claim is, that until the student have not chosen all the options, she could have some points. However, choosing three of four options could mean a try of guessing. Although in this case the student gets the full amount of basic points, she is fined on a half of them.

Table 6: Comparison of the proposed approach with other existing approaches.

Dich.	MTF	Morgan	Ripkey	Balanced
0	0.8	0.67	0	0.67

Example 6 (Case: 5 options, 2 correct, 2 correct and 1 incorrect marked)**.** *The example shows the disadvantage of the Ripkey algorithm more clear. It is not clear for the student, why she was awarded zero points, as she did not try to guess and answered partially correct.*

Table 7: Comparison of the proposed approach with other existing approaches.

Dich.	MTF	Morgan	Ripkey	Balanced
0	0.6	0.17	0.67	0.67

Example 7 (Case: 5 options, 3 correct, 2 correct and 1 incorrect marked)**.** *In that case balanced scoring and Ripkey algorithms behave the same, as none of them deducts a penalty.*

4.2 Real-life Evaluation

We have implemented the balanced scoring method within our e-learning system SlideWiki[3] (Khalili et al., 2012). For evaluation of our algorithm we used a lecture series on “Business Information Systems”. We chose this course since it comprises a large number of definitions and descriptions, which are well suited for the creation of MMQs. In total we have created 130 questions. A course of 30 students was offered to prepare for the final examination using SlideWiki. Overall, the students made 287 attempts to complete the quiz and we collected all their answers (also unfinished assessments) for the evaluation. After collecting the answers, we implemented all discussed algorithms to score and compare the results, in particular with regard to the ranking and the mean score. The results are summarized in 1.

The study aimed to investigate two aspects of the proposed approach:

- How severe does the balanced scoring approach penalize?
- How does balanced scoring differ from Dichotomous scoring?

We answer the first question by comparing the scores calculated using all discussed algorithms for the same quiz (see 1, upper part). These two diagrams show, that on average the balanced scoring approach penalizes more severely than MTF scoring and less severely than other discussed approaches. We answer the second question by comparing the difference in student ranking. We rank all assessments based on the individual scores. That is, assessments with higher scores rank higher than assessments with lower scores and equal scores result in the same ranking. We compare the rankings of other approaches with the rankings calculated using the dichotomous scoring, since we consider the dichotomous scoring to be the ranking reference. The two lower diagrams in 1 show the results of this evaluation. They show, that the ranking of the balanced scoring approach is the closest to the dichotomous ranking when compared to the other algorithms.

5 CONCLUSIONS

In the paper we evaluate the existing approaches for scoring the multiple-mark questions and propose a new one. The proposed approach has a list of restrictions, however it has advantages when compare with the discussed approaches. One of the main advantages is that is based on the mathematical model, it does not suffer from the skewness, as it has the same formula for all cases. At the same time, the proposed approach recognizes the attempts to guess the correct answer, for example choosing all the possible options. When compare with the existing approaches, the advantages of the proposed algorithm could be summarized as follows:

- The approach allows to score both multiple-mark and conventional multiple-choice questions.
- The approach is based on the partial scoring concept.
- The algorithm can be easily implemented, it is pure mathematical.
- The score does not highly depend on the amount of correct and incorrect options.
- The value of the penalty is in balance with the possibility, that the student is trying to guess.
- Due to the balance, the results are clear for the students.

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[3] http://slidewiki.aksw.org

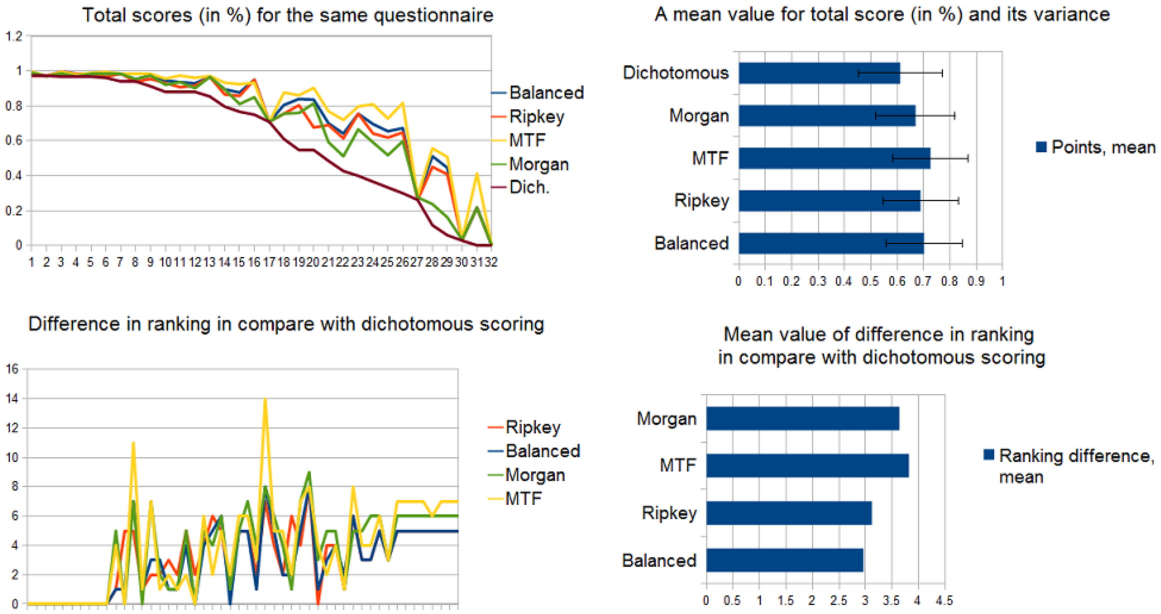

Figure 1: The statistics of the evaluation.

However, we suppose our algorithm to be optional together with other discussed approaches. This is due to the fact, that teachers create questions in their own manner and should be able to choose an appropriate method to score the results. Also, the different situations require different levels of severity, and the proposed approach might be too lenient.

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e-Inclusion and Knowledge Flows in e-Course Delivery

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Keywords: e-Inclusion, Digital Skills, Knowledge Flows.

Abstract: Our purpose of the study was to use the acceleration of knowledge flow to predict practical use of digital skills. For this purpose, we identified certain variables to be correlated for practical uses probability as a guide for their effectiveness for e-learning assessment. The study was based on evaluating a group of five hundred learners. We designed four types of questionnaires and one telephone survey to assess different aspects of the course topics that affect the practical uses of digital skills. We applied knowledge management theory, basic principles of classical mechanics and statistical analysis. We developed a formula for linear regression equations for practical uses of digital skills probability. As potential predictor for effective delivery of different topics of an e-learning course we obtained knowledge flow acceleration. The results indicated that one of the factors for determining practical uses probability in the e-inclusion model for an e-learning course was related to knowledge flow acceleration.

1 INTRODUCTION

This study aims to address the issue of how to facilitate the inclusion of everybody to enjoy the benefits of information and communication technology (ICT) (European Commission, 2010). The progress report of the EU Digital Agenda states that there still exists a sharp divide in digital use in Europe between different population groups (European Commission, 2011).

Nowadays the digital divide goes beyond the issue of access to technology (Deursen and Dijk, 2009). The focus has shifted from access to ICT to the meaningful use of ICT (Hargittai, 2000); (McLean, 2006). Learning new skills and using them are two separate steps (Lerchner et al., 2007).

This article is concerned with the second digital divide, where individuals does have some digital skills but lacks the ICT skills needed to fully engage in their chosen professions. The second digital divide is a significant issue for many professions and population groups. This article will focus on teachers who were the target group of our study. Our study shows that vocational teachers are increasingly expected to use ICT as a teaching and administrative tool. This issue has been pointed out by the European Commission and a number of scholars who have studies this problem (Uzunboylu and Tuncay, 2010). Digital literacy has today become a "survival skill" for teachers. But teachers often exhibit low self-confidence when applying digital skills to teaching and other professional requirements. Scholars have noted the critical nature of this deficit and argue for the importance of providing teachers with the training needed to allow them to take full advantage of available ICT opportunities (Abrantes et al., 2007); (Cort et al., 2004).

A number of studies have been done regarding the e-inclusion process (FreshMinds and UK Online Centres, 2007). However, there is no unified point of view on how to facilitate the practical use of learned digital skills. This paper continues the authors' investigation on how to promote practical use of learned digital skills (Vitolina and Kapenieks, 2012). The study contributes to research of the factors influencing meaningful ICT use in e-learning contexts by applying knowledge management methods. In this paper it is argued that practical use probability is related to knowledge flows acceleration.

2 KNOWLEDGE FLOWS PROCESSES

Knowledge flows processes are dynamics, they flow in different directions and at different speeds. To determine what laws govern the knowledge flow processes several authors based their research on basic laws of physics (Hu and Wang, 2008); (Zhuge et al., 2007). Moreover, Nissen used principles of classical mechanics to describe, explain, and predict knowledge flows processes (2006). For instance, knowledge at rest tends to stay at rest. But some kind of force is required for knowledge at rest to move. Additionally, Nissen applied Newton's famous law: F = ma (that is, force equals mass times acceleration) to analyze knowledge flow processes. According to Nissen, the teacher may represent a force but a simple chunk of knowledge may represent the mass. This means that "the gifted teacher and a simple concept may create rapid and broad knowledge flows. A less-skilled teacher and more complex knowledge may result in comparatively slow and confined knowledge flows, or even no flows at all" (Nissen, 2006, p. 32).

The role of the instructor in sharing knowledge decreases in the e-learning or blended e-learning course. Knowledge sharing depends upon the quality of the content, i.e. learning materials, and the usability of the e-learning environment for convenient use of content and communication with the instructor. We proposed in the e-learning course context to expand the meaning of force (1). We assumed that force (KFF) is related to the instructor's willingness to share knowledge (IWS) and to usability of e-learning environment (eLE) and quality of e-learning materials (eLM). We included student's self-evaluations of his knowledge level before learning of the e-course topic (KLBL) in the force equation as well. We summed values of the instructor willingness to share knowledge, evaluation of the e-learning materials and e-learning environment because they all together present the "teaching force". We determined that students' knowledge level before learning is a critical value for acquiring new knowledge. Therefore, we used KLBL as a multiplier.

$$KFF=(IWS+eLE+eLM)*KLBL \qquad (1)$$

We proposed to determine the variable knowledge flow mass (KFM) by the complexity of the e-course topic (CT) (2).

$$KFM=CT \qquad (2)$$

According to Newton's law Knowledge flow acceleration (KFA) is knowledge flows force divided by knowledge flows mass (3).

$$KFA=KFF/KFM \qquad (3)$$

3 PURPOSE OF STUDY

Our purpose was to use the acceleration of knowledge flow to predict practical use of digital skills for vocational teachers after completing the e-course "Improvement of ICT skills".

4 METHODS

4.1 Participants and Assigned Topics

Our participants were 500 vocational teachers. The testing sample covered 80% of the participants in the blended e-learning course "Improvement of ICT skills". The topics for the course related to the improvement of instrumental knowledge and skills for tool and media usage, advanced skills and knowledge for communication, information management, and meaningful participation in a knowledge society. We analyzed eleven of these topics. They included: setup of peripherals, Image scanning, Web page design, PDF files, Computer security, MS Access, Video processing, E-learning materials, Social networks, Excel and e-mails. Each topic included theoretical material in video and text format and tests for knowledge assessment.

4.2 Measures

We designed four types of questionnaires to assess different aspects that affect the practical use of digital skills. The questionnaires collected information about students' knowledge level before and after each topic that included e-learning environment usability, e-content quality, instructor's willingness to share knowledge, and student's predicted use of digital skills after completing e-course. We used a Likert-type questionnaire on a scale that ranged from 1 – strongly disagree to 5 – strongly agree.

Additionally, we designed a telephone survey to obtain data about the practical use of digital skills after completing the e-learning course. For each topic the students were classed in the three categories depending on usage level of digital skills.

We also classified all topics in the three groups according to their complexity in the range from 1 to 3.

Predictors. One predictor was knowledge flow force (KFF). This was measured by four independent variables: (I) students' evaluation of instructor support in classroom seminars and in the e-learning environment (IWS); (II) students' evaluation of e-learning materials for the course (eLM); (III) students' evaluation of e-learning environment (eLE); (IV) students' self-evaluations of their knowledge level before learning of the topics (KLBL).

The second predictor was knowledge mass. This predictor was measured by the independent variable: the complexity of topic (CT).

Criterion Variables. Practical use probability was the criterion variable. We determined it by three variables: (I) students' prediction of digital skills practical use (by means of the questionnaire), (II) observed practical use of digital skills (by means of the telephone survey) and (III) practical use (by mean of the combination of predicted and observed use).

4.3 Procedure

Data collection. We collected the data from the students by means of questionnaires administered from January 2012 until April 2012. The questionnaires were a section part of the blended e-learning course for digital skills improvement and could be accessed through the Moodle learning system. Moreover, we conducted telephone surveys by phone from March 2012 to May 2012 to determine the extent to which practical use of learned digital skills were applied four to twelve weeks after the course. The number of respondents for each topic differs from 57 to 86 because the completing of the questionnaires was voluntary.

Data analysis. The authors employed correlation and regression calculations with the SPSS for Windows (version 17.0) for analysis.

5 RESULTS

5.1 Knowledge Flow Acceleration

The first step in this study was to calculate the average of the Knowledge flow acceleration (KFA) for all topics following the formula (3). Maximum KFA (100% of possible KFA) was not observed. Our obtained results showed that the percentages of KFA could vary from 38% to 65% (Table 1). Moreover, we observed that the KFA was lower for the topics MS Access (38%), Web page design (38%) and MS Excel (40%). But KFA was higher for other topics such as improved skills for e-mail usage (65%), how to scan image (53%), and how to find e-learning materials on the Web (52%). Our study indicated that knowledge flow acceleration varies according to a topic.

Table 1: Maximum values of the knowledge flow acceleration for various topics.

Topic	KFA (%)
E-mail	65
Image scanning	53
E-learning materials	52
Setup of peripherals	49
PDF files	48
Video processing	47
Social networks	47
Computer security	46
Excel	40
Web page design	38
MS Access	38

5.2 Correlations of Knowledge Flow Acceleration

Then we analyzed the correlations between the percentage of maximum possible knowledge flow acceleration and digital skills practical use probability. Table 2 shows correlation coefficients for all topics.

For all topics predicted use has a statistically significant correlation with knowledge flow acceleration. The topics themselves have medium correlation in the range from .377(**) to .618(**). The highest correlations are for the Video processing topic.

Next, we analyzed observed use. Table 2 shows that correlation between observed use and knowledge flow acceleration is statistically insignificant for most of the topics. In four topics observed, use has a statistically significant correlations in the range from .310* to .392**.

Furthermore, we examined a combination of predicted and observed use. Table 1 illustrates that for all topics the correlation is significant. Moreover, most topics have medium strength correlations in the range from .411(**) to .628(**). The highest correlation is for the topic Social networks. Only one topic MS Excel has correlations that are significant at the 0.05 level: .273(*).

In this study it was found that knowledge flow acceleration is a predictor of the learned skills practical use possibility for vocational tteachers.

Table 2: Correlations between knowledge flow acceleration and probability of practical use.

Topic	PU	OU	PU&OU
E-mail	.423**	.079	.411**
Image scanning	.508**	.184	.490**
E-learning materials	.490**	.215	.479**
Setup of peripherals	.452**	.154	.419**
PDF files	.464**	.387**	.521**
Video processing	.618**	.216	.608**
Social networks	.545**	.392**	.628**
Computer security	.442**	.310*	.524**
Excel	.377**	.023	.273*
Web page design	.524**	.021	.442**
MS Access	.475**	.329**	.518**
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). PU – Predicted use; OU – Observed use			

5.3 Linear Regression for the Knowledge Flow Acceleration and Practical use Probability

The results shown on Table 3 demonstrate R Square of the linear regression models. There is a significant relationship ($p < 0.05$) between knowledge flow acceleration and predicted use of digital skills for all the topics, the exception is Excel topic. Moreover, there is a significant relationship between knowledge flow acceleration and predicted and observed use of digital skills.

The linear regression model explained 18% to 38% of the total number of variations for predicted use. The highest percentages of variations were for the Video processing topic. The lowest percentages were for E-mail topic.

For the combination of the predicted and observed use the regression model accounted for 17% to 39% of the variance. Video processing topic had the highest percentage. Again, E-mail topic had the lowest percentage of the identified variations.

Table 4 and 5 present equations for regression models of predicted uses as well as the combination of predicted and observed uses.

Regression coefficients are in the range from 0.027 (E-mail) to 0.125 (Video processing) for the predicted use model. In the model combination of predicted and observed use, regression coefficients are in the range from 0.029 (E-mail) to 0.155 (Video processing).

Table 3: R Square of linear regression model of predicted use (PU) and combination of predicted and observed use (PU&OU).

Topic	R Square PU	R Square PU&OU
E-mail	0.179	0.169
Image scanning	0.258	0.240
E-learning materials	0.240	0.229
Setup of peripherals	0.204	0.176
PDF files	0.215	0.271
Video processing	0.382	0.370
Social networks	0.297	0.394
Computer security	0.196	0.275
Excel	0.142	0.075
Web page design	0.275	0.195
MS Access	0.225	0.269

Table 4: Linear regression equations for predicted use of digital skills.

Topic	Equation
E-mail	$PU=0.027KFA+3.069+\varepsilon$
Image scanning	$PU=0.060KFA+2.836+\varepsilon$
E-learning materials	$PU=0.029KFA+2.779+\varepsilon$
Setup of peripherals	$PU=0.057KFA+2.836+\varepsilon$
PDF files	$PU=0.058KFA+2.937+\varepsilon$
Video processing	$PU=0.125KFA+2.262+\varepsilon$
Social networks	$PU=0.041KFA+2.433+\varepsilon$
Computer security	$PU=0.053KFA+3.324+\varepsilon$
Web page design	$PU=0.121KFA+2.129+\varepsilon$
MS Access	$PU=0.097KFA+2.540+\varepsilon$

The value of constants of the regression equations is in the range from 2.129 (Web page design) to 3.324 (Computer security) for the predicted usage model. However, in the model for combination of predicted and observed use, the range of constants are from 2.492 (Web page design) to 4.174 (E-mail).

In this study it was found that the relationship between knowledge flow acceleration and practical use of digital skills can be modeled by a linear regression equation.

Table 5: Linear regression equations for combination of predicted and observed use of digital skills.

Topic	Equation
E-mail	PU&OU=0.029KFA+4.174+ε
Image scanning	PU&OU=0.074KFA+3.756+ε
E-learning materials	PU&OU=0.037KFA+3.606+ε
Setup of peripherals	PU&OU=0.068KFA+3.796+ε
PDF files	PU&OU=0.093KFA+3.293+ε
Video processing	PU&OU=0.155KFA+2.564+ε
Social networks	PU&OU=0.056KFA+2.691+ε
Computer security	PU&OU=0.079KFA+3.974+ε
Web page design	PU&OU=0.123KFA+2.492+ε
MS Access	PU&OU=0.137KFA+2.559+ε

6 DISCUSSION

The purpose of the study was to predict whether the knowledge flow acceleration has an impact on the practical use of newly learned digital skills for vocational teachers.

First, we observed that for different e-course topics the average of the knowledge flow acceleration varies. Second, our study indicated that knowledge flow acceleration is a predictor of the practical use of newly learned digital skills for vocational teachers in an e-course context. Third, we proposed the linear regression model for predicting practical use possibility for different e-course topics.

On the one hand, our findings about knowledge flow acceleration for the topics means that the level of their complexity may vary. The rate of acceleration was lower for topics that were related to specific software. For example, MS Access, Web page design, and MS Excel. However, acceleration was higher for topics that encompassed lighter themes such as e-mail, image scanning and searching the web for e-learning materials. On the other hand, the variations in knowledge flow acceleration for the assigned topics may also be explained by other factors: the different knowledge levels that the students possessed upon entering the course, the quality of the e-learning environment and materials, and the instructor's willingness to share knowledge.

Furthermore, knowledge flow acceleration was predictor of the practical use of ICT skills possibility. That means that a higher acceleration of knowledge flow leads to a higher possibility of a meaningful use of ICT. Our results showed that the rate of acceleration is related to the instructor's willingness to share knowledge, the quality of the e-learning environment and materials and the student's knowledge upon entering the course.

Our results confirmed the research of our previous study regarding the significance of e-learning material and environment quality as predictors of practical use of digital skills (Vitolina and Kapenieks, 2012). Our findings are in accordance with the results obtained by others researchers studying these issues who argue that when learners felt positively about the quality of the training (learning materials, and environment), they were able to acquire more knowledge and apply acquired skill to their professional and practical lives (Sulčič and Lesjak, 2009).

Our other results indicated to us how various factors influenced future use of newly acquired ICT skills. The models that we developed to profile the linear regression calculations showed that the variation range was 17% to 39% for the different e-course topics for practical use possibility. That means that not only knowledge flow acceleration but also other factors could impact upon learning behavior after e-course completion. We are going to continue our research regarding the other factors that reveal student attitudes, interests and capacity to learn.

Our results for regression coefficients equations indicated that depending on a topic's average value, practical use possibility generally increases by 0.027 to 0.155 for each additional unit that knowledge flow was accelerated. We observed that for more complex topics such as Web page design, Video processing and MS Access practical use possibilities increased at a slower rate than for other topics. We concluded from these results that to reach a higher practical use possibility level for complex topics it is necessary to provide high quality e- learning materials and e-learning environment. Additionally, the instructor's willingness to share knowledge and the learner's knowledge level upon entering the course should be at a high level.

A few methodological limitations should be noted. The sample used in the current study included only vocational teachers and the sample size for specific course topics was relatively small. Further study with a larger sample is needed to analyse the validity of the current findings to obtain more comprehensive and realistic data about practical use of learned digital skills it is necessary to prolong the period of vocational teacher observation from three to six month after completing course training.

7 CONCLUSIONS

Our results identified factors that promote e-inclusion. We concluded that a higher rate of knowledge flow acceleration predicts a higher use possibility of newly acquired digital skills by vocational teachers after e-course completion. The results confirmed the importance of designing quality e-learning materials and e-environment to attract e-excluded individuals. Other important factors that promote e-inclusion are an instructor's capacity to share knowledge and student's knowledge level upon course entry. The implications of the research should encourage organizations and enterprises that are responsible for e-course design to take these factors into account in their future development efforts.

This study addressed the issues concerned with the second digital divide. It focused on identifying relevant factors for narrowing the second digital divide that inhibited vocational teachers from applying digital skills in a meaningful way and showed ways to remove these obstacles so that these teachers could meaningfully participate in their professions and enrich their personal lives. In our study knowledge flow acceleration served as a potential predictor for the effectiveness of e-course delivery for the various topics we had assigned. Moreover, we developed a linear regression model for predicting practical use probability for designing post-course surveys that can measure the long-range impact of a delivery e-course.

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Maintaining Context in a Changing (Virtual) World
Educators' Perspectives for Opensim and Second Life

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Keywords: Virtual World, Second Life, Opensim, Context, Virtual Learning, Blended Learning.

Abstract: Educational activities previously performed in Second Life are now more and more move moving to other alternatives. This study concentrates on the features of Second Life and its open-source alternative, OpenSim that affect the results of the in-world educational activities. The need for educators to take these features into account is another focus of this study which also aims to highlight the similarities and differences between the contexts of Second Life and OpenSim worlds, whether internally or externally hosted, as well as their potentials and weaknesses. The findings suggest that each one of these alternatives gathers different positive and negative features and their suitability greatly depends on the academics' educational needs.

1 INTRODUCTION

Due to the availability of the OpenSim (OS) architecture it is nowadays comparatively easy to install and run a Virtual World (VW) that in appearance very much resembles a 'Second Life' (SL) environment. Such worlds can belong either to individuals or companies, organisations and institutions. They can be self-maintained or rented from a dedicated provider. However, the educational activities in OS and SL operate in a very different context implicating upon the immersive experience.

It has been indicated that immersion is an essential factor for achieving satisfactory learning results within the context of a VW (Bredl et al., 2012); (Childs, 2010). The networks of various interactions that occur within the VWs are noted as the most important among the various factors that lead to immersion (Kanamgotov et al., 2012); (Christopoulos and Conrad, 2012).

At this point, some important questions arise when a VW is to be used for educational purposes: what is the role of its context to the students' way towards immersion? How can its context contribute to the implementation of successful educational projects? And finally, when an educator has to choose among SL, an OS world hosted by a dedicated provider (OSDP) and an institutionally hosted OS world (OSIH), which one is the best option as far as their contexts are concerned?

This paper is focused on answering these questions and providing clear guidance to educators who are faced with the decision to use SL or OS worlds –hosted either institutionally or externally– for the realization of successful educational projects.

The student perspective concerning VWs has been widely investigated, (for example Vrellis et al., 2010; Kostarikas et al., 2011; Levesque and Lelievre, 2011); we focus here on the educator's point of view.

2 RELATED WORK

In this paper, the term "context of a VW" refers to everything that exists or takes place within the VW, including the virtual land, the avatars, the users' artefacts, and the interactions between them.

SL and OS have many similarities concerning their basic characteristics (Cram et al., 2010), on the one hand, but they have many differences, on the other, which should be carefully taken into account when these VWs are to be used for educational purposes (Conrad, 2011); (Conrad, 2013).

2.1 Avatars

Avatars are the users' virtual selves or, rather, the users' 3D self-representations in a VW through which they are able to be in it, and interact with it and with each other (Savin-Baden, 2010).

A common view of several scholars (Kostarikas et al., 2011); (Bredl et al., 2012); (de Freitas et al., 2012) is that avatars are a feature of VWs which enhances the effectiveness of the educational activities. On top of that, Bredl et al. (2012), de Freitas et al. (2009), Levesque & Lelievre (2011), and Kay Michel et al. (2011) underline that the use of avatars contributes to the development of the users' immersion, which, in turn, leads to better outcomes from the educational activities.

2.2 The Worlds' Content

There seems to be agreement in literature to consider the content of both SL and OS equally useful and appropriate for educational purposes. More precisely, Miller et al. (2010) emphasize the importance of students' easy access to learning materials and the potentials for experiencing interactive educational activities offered equally in both worlds. Similarly, Aydogan et al. (2010) indicate the significance of the 3D visualizations of the educational material created within virtual classrooms, which may contribute to a better understanding of the lesson by the students.

Callaghan et al. (2009) also agree with the statements above and add that the environments of both VWs and the tools provided for creation enhance the students' collaborative abilities, who work together aiming to create the world's context and carry out their projects. Konstantinidis et al. (2010) partially agree with Callaghan et al. (2009). They suggest that the 3D representations that may be created in OS have a positive effect on the collaboration among students, creating a sense of belonging in the VW and thus promoting immersion into the developed world. In other words, it is their common claim that collaboration among students is enhanced within the context of VWs, but each of them presents a different aspect as the reason of that enhancement.

2.3 Interactions

Even though SL and OS offer great opportunities for interactions among their users and between the users and the worlds' content (Levesque and Lelievre, 2011); (Zhao et al., 2010), very few studies have been carried out in relation to the interactions between the users and the context of the VWs. However, both the interactions among the users of VWs and the interactions between the users and the context of the worlds significantly affect the educational processes performed in them (Vrellis et al., 2010).

The given opportunities for manipulating virtual objects and interacting with the virtual environment and other users make the educational projects that take place in-world pleasant (Perera et al., 2010a); (Vrellis et al., 2010), interesting (Perera et al., 2010a); (Kostarikas et al., 2011); (Vrellis et al., 2010) and effective (Vrellis et al., 2010). According to Miller et al. (2010) these specific characteristics contribute to the strengthening of the collaborative and exploratory learning activities and ensure student participation in them. Moreover, the manipulation of virtual objects in the context of a VW is less disruptive and more preferred by students than the use of other e-learning tools, whilst the environment enhances the interactions among the members of a student group, thereby enabling the effective implementation of collaborative learning activities (Vrellis et al., 2010).

The only drawback in using these VWs for educational purposes concerns the inability of using the non-verbal communication channels (Childs, 2010); (Vrellis et al., 2010). On top of that, the use of text chat may be very time consuming, disruptive, and inefficient, a fact that complicates the in-world educational activities and, combined with the absence of non-verbal communication, further complicates communication within the students' group (Child, 2010). Hence, Vrellis et al. (2010) do not fail to express their conviction that the educational processes within VWs will never be able to replace the traditional teaching methods but will always serve as a complement and as a useful tool in providing additional educational opportunities.

2.4 Security & Privacy Issues

An important factor in ensuring universities' safe operation within the VWs concerns the protection of their virtual land against intruders. Savin-Baden (2010) states that the best way for universities to deal with this issue in SL is to buy isolated islands. Perera et al. (2010b) insist that both in SL and in OS, the academic institutions are able to allow entry to avatars which are "marked" as their students, and prohibit entry to unwelcome users. On the other hand, Hu (2010) stresses superiority of the OSIH, as far as their security level is concerned. In these servers, the institutions can fully control which avatars may be registered in them. Meanwhile, these avatars can be transferred to other servers in order to explore them and come into contact with others using hypergriding (Korolov, 2010).

3 RESEARCH METHODOLOGY

The Grounded Theory approach, as described by Strauss & Corbin (1998), was thought to be the most suitable qualitative analysis approaching method; the interview questions were formed in accordance with the indications of Strauss & Corbin (1998), whilst the findings of the literature review also shaped their content, in particular we asked:

1. What does a typical session of yours look like in SL's/OS's virtual environment?
2. Why do you use SL/OS in your teaching? In your opinion what are the advantages of this teaching method?
3. Respectively, are there any disadvantages?
4. Comparing the university classroom with the virtual classroom, which one may have better results?
5. Which one of these two virtual environments do you consider more appropriate for educational use?

During a four-month period (January to May 2012) a total of 34 academics (20 of them have used only SL, 2 only OS and 12 both of them) from various educational fields were interviewed via Skype, SL, or in person. The educators were asked to express their opinions regarding the contexts of SL and OS, their advantages and disadvantages and also their effects on the educational activities based on a priori formed questions. Given the content of the questions, not all of them were addressed to all participants. Besides, the educators' empirical perspectives were what these interviews were seeking for. Thus, questions 1, 2, 3 and 4 were addressed to the educators who had used SL and/or OS (the latter one either internally or externally hosted). Finally, the participants who had used both SL and OS were asked to answer the fifth question and compare these two VWs.

Following the qualitative analysis of the responses according to Strauss and Corbin's (1998) methodology we present our findings in the next section.

4 FINDINGS

Both the advantages and the disadvantages of the context of SL and OS were considered important to be examined. Simultaneously, a summary of the educational activities that may take place within these VWs will be presented with the aim of informing educators and providing guidance on how to use them.

4.1 Critical Evaluation of the Contexts

The positive elements of the contexts of SL and OS were emphasised whilst corresponding emphasis was also placed on their drawbacks seen from an educational viewpoint. Although certain positive and negative features are unique to each one of these contexts, several others are common to both of them. Besides, the similarity of the OS context to the SL context, combined with the fact that it is open-source software, was highlighted as a very fundamental feature of OS.

Several educators stressed that the use of VWs, in general, is an innovation in education. As a consequence, the in-world learning activities attract students' interest, engage them in the educational processes and therefore produce better learning results (see Christopoulos and Conrad, 2012 for more details). Furthermore, the contexts of both VWs were marked as user-friendly, playful, dynamic, and plausible.

As participants stated, all these SL and OS features are especially beneficial to the preparation and successful implementation of various educational activities that will be both attractive and effective for most of the students. Students' freedom to take advantage of these features, interact with the context of the worlds, participate actively in the development of the virtual content with their creations, and explore others' creations contributes towards the same goal. In both cases, the amount of the experience they receive from their participation in various activities increases.

The accessibility of SL, which results in the coexistence of a wide online community which contributes to the in-world creation of a global context valuable for numerous educational activities, was noted as a significant advantage of it. These features combined with the anonymity that is typical of SL enhance the immersiveness of this VW, as indicated by some participants. Educators who use SL can be benefited from its global context and reduce the time and effort required for building and scripting, simply by using the existing in-world infrastructures or visiting its marketplace.

OS worlds have narrow online communities due to the fact that they are hosted on many independent servers. This implies that the content of OS –either IH or DP– is very limited, compared to that of SL, sometimes even completely non-existent. Therefore the educators who use OS reported that the creation of the necessary content for their educational activities is a time and effort consuming process and requires the possession of building and scripting skills as well. Nevertheless, OS users can visit other OS worlds using the hypergrid architecture in order to explore other places and communicate with others.

On top of that, the OSIHs are independent, closed and protected from intruders, and their access control lies exclusively in the educators' hands. In contrast, universities in SL are confronted with several security and privacy issues which result from its accessibility.

It is also worth mentioning that the educators who use OS emphasised that they have absolute control of their world and a high degree of independence, especially in the case of OSIHs. They attributed these features of OS first to its open-source nature, which allows them to develop worlds perfectly suited to their educational needs, second to the ability it offers them to keep backups of their world, something which preserves the content of their worlds invariant and available for reuse, and finally to the fact that OS worlds have no global online community. The last feature allows educators to be fully aware of the users who access their world, whether this is institutionally hosted, where the university holds the in-world access rights management, or externally hosted, where the university can choose a provider which hosts an acceptable one to the university community.

On the other hand, educators using SL depend directly on Linden Lab: they should seek support from Linden Lab when they encounter issues related to their region and, on top of that, several educators underlined the lack of support by Linden Lab in a rather disapproving tone.

Several educators made particular reference to the use of the plugin tools which are compatible with SL. Some of them referred to the collaborative and the distance learning tools which they use in the context of SL in order to support and enhance their educational activities. These tools are fully or partially compatible with the OS technology as well. However, this was mentioned by none of the interviewees using OS.

Not only do these two VWs have many positive features in common but they also have many drawbacks. The use of any VW for educational purposes presupposes that one or more sessions are devoted to the students' familiarization with the context, the tools, and the navigation system of the VW, a process usually called "orientation".

Orientation was deemed necessary by the educators but, at the same time, time-consuming which is thought to be a significant drawback of any educational practice. Students' orientation and the use of VWs in general, are hindered by the fact that SL and OS are not intuitive enough to allow new users to "feel" their contexts. Besides, the internal communication is sometimes problematic, due to poor VoIP quality, and face-to-face communication is not an option.

Additionally, several participants appeared dissatisfied with the graphical user interface of both worlds, because it makes them even less intuitive. Moreover, the incompatibility of MS Office and Open Office with the SL and OS environment (documents need to be converted to images) was mentioned in several interviews as a significant concern.

Due to the technical issues identified in both VWs, the quality of the implementation process and the results of the learning activities are degraded. The educators raised concerns about the considerably high technical requirements of both worlds, since the use of sufficient computer systems with high minimum standards is demanded for the proper rendering of the VWs. In cases where these requirements are not met, users face several rendering issues, such as latencies, deficient and problematic display of the in-world content, and the like.

4.2 The Effects Applying on the Educational Activities

The interviewees, taking into consideration the positive and negative features of the context of each VW, concluded that both of them are worth being used for educational purposes.

Carrying out learning activities within SL and OS has multiple positive effects on students' education. First and foremost, educators are given the opportunity to pursue the so-called "edutainment" which fosters higher levels of student engagement with the educational activities. Furthermore, the plausibility, the interactivity, and the dynamic nature of the contexts of these worlds combined with the high level of freedom provided to users allow the realization of projects which are too costly, or too dangerous, or even impossible to be carried out in the physical world. Besides, the flexibility of the contexts of SL and OS permits complete control of the laws of physics. Moreover, several educators consider the opportunity given to their students to build and script and then observe the functionality of their creations as very constructive. This is a very useful feature of SL and OS, especially for students involved with Information Technology, Virtual Reality, 3D

Animation, and similar disciplines.

Apart from the highly regarded advantages of the use of SL and OS in education, the academics did not disregard the drawbacks that possibly arise from the use of the two VWs under study. The participants considered it necessary to remark that the preparation and implementation of in-world educational activities is a fairly complicated process, Additionally, the rich context of VWs, with the various stimuli, the vividness of the representations, and its playful nature, often distracts students' attention during educational sessions, whilst the high level of the in-world experienced freedom quite frequently results in discipline problems.

Finally, it was reported that some students struggle to understand the way their avatars are navigated and the in-world tools are used, even after the orientation session, and it is this difficulty that can also distract them from their activities. These students consider VWs as non-intuitive spaces, thus the in-world educational activities in which they participate do not have the desired results.

4.3 The Educational Activities

The participants claimed that they use VWs in the framework of the blended learning approach, that the activities they design and carry out contain the element of content creation, and that these activities are very often simulations. Activities associated with problem-based learning and role-playing are usually conducted within both worlds. The educators emphasised that all the activities related to these modes of learning have much better quality, structure, and results when carried out in the context of a VW whether this is SL or OS. Moreover, in some cases VWs are used to host presentations and lectures.

A significant differentiation between the two VWs is that SL is frequently used for the conduct of exploratory learning activities, such as treasure hunt, whereas similar activities are not performed equally often in OS. This can be attributed to the content of SL which is much wider and richer compared to the OS worlds. Furthermore, SL is used to cover distance learning needs more often than OS worlds which are not as accessible as SL.

Finally, deciding on the physical classroom is most purposeful in cases where the educational objectives extend beyond the simple practice of skills and require students' higher level thinking. Also, when the educational project to be carried out is very brief and fast-paced the use of the physical classroom is preferable, since the preparation and implementation of activities within VWs requires quite a lot of time in order for them to be successful.

5 CONCLUSIONS

The use of VWs, in general, and of SL and OS, in particular, is considered purposeful only when very specific educational needs, which cannot be fulfilled in an equally effective way with other educational tools, are to be met. Using them without a specific aim, just because they are considered a contemporary trend, is not recommended. This view is fully justified given that both SL and OS present not solely a very positive and useful for both educators and students context, but a negative one too. Therefore, it is advisable that educators use these worlds only in cases where the maximum possible exploitation of their positive context with minimal influence from the negative is likely.

It also seems that the ideal use of VWs can be pursued through the use of blended learning approaches, in which students are presented with the course material both virtually and in the university classroom. Thus, the educational processes derive maximum benefits when both the virtual and the physical classroom are employed. Activities related to content creation, problem solving, role-playing, simulations, and collaboration can bring the best possible results when attempted within the VW. On the other hand, activities, such as lectures and presentations, that presuppose face-to-face communication, which is absent from VWs, usually have better results when given in the physical world.

Comparing SL to OS, it seems that the former is more appropriate for the implementation of activities in which the communication of the students with non-student users, or remote student-users and the utilization of the global context of the world are considered as essential requirements. On the other hand, OS worlds are believed to be the best choice for these educators who seek closed, protected, and flexible workspaces. These features can be found in the OSIHs. These worlds are completely closed, protected and the university has full control over their context and the users who can access them. This implies that these worlds can accommodate only the content that the university has approved. Meanwhile, the institutions are able to adjust the world, its specifications, and its tools to their students' learning needs.

Finally, the option of an OSDP is the middle ground between the OIHs and SL. Its context is usually wider than the one of the OSIHs. It hosts a limited online community that is likely, however, to develop a network of interactions, which is not as wide as the one of SL but it is wider than the one developed in the OSIHs. Moreover, since its online community is limited and the communication with the provider, most of the times, direct and easy, the educators are able to be aware of the characteristics of this community. Anyhow, educators are entitled to choose the most suitable server for their needs depending on the community that each world hosts as well as the appropriateness of the in-world content.

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Business Process Modeling and Implementation

A 3-Year Teaching Experience

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Keywords: Business Process Modeling, Workflow Modeling, Petri Nets, Swim Lanes, Novice Errors, MS SharePoint.

Abstract: In this work we describe a three-year teaching experience in an Information Systems course for a Management Engineering Master degree, where the course's focus was on business process modeling and on the technical aspects related to process implementation in a commercial software suite. In particular, we underwent a modeling shift from a Petri Nets description of concurrent processes to a full, business-process oriented methodology as proposed by Sharp and Mc Dermott (Sharp and McDermott, 2001) (Sharp and McDermott, 2008). This latter methodology was extended with additional data models, such Entity Life History, dealing with entities life cycle and dynamics. The students engaged in modeling the business processes of a real Small Medium Enterprise operating in the local area. The model was implemented using Microsoft Share Point, which affords a tight integration with databases such as Access or Microsoft SQL Server. A comparison of the adopted modeling strategies is presented, as well as common student errors in the design and implementation phase, together with some lessons learnt.

1 INTRODUCTION

Business process modeling is an important topic that is gaining momentum in modern curricula, both at the undergraduate and graduate level (Topi et al., 2010). In a recent review (Bandara et al., 2010) the authors presents the Business Process Management (BPM) instruction programs in five universities around the globe. In their work the author identifies three major trends in BPM:

1) Methodologies to organize, manage and measure the organization based on its core processes;
2) the lean Six-Sigma BPM;
3) The technological trend that focuses on enabling the organization core process through BPM platforms emphasizing the technical aspects of BPM as “a set of new software technologies that make it easier for IT to manage and measure the execution of process workflow and process software applications” (Harmon and Wolf, 2008).

The authors identify, among the major challenges, the following ones:

1) difficulties in teaching the technical aspects of the topic, since both specialized skills and more time to set up and teach than other existing courses are required. The higher workload results, among other things, from testing in a complex technological environment in order to offer to the whole class a reliable platform;
2) only a limited pedagogical research specific to BPM education is available.

A recent interesting work (Djajalaksana, 2011) presents the results of a national survey in the United States on the instructional strategies used related to teach Information Systems (IS) courses.

This paper aims at contributing to current pedagogical research in Business Process Modeling and Management by reporting a teaching experience carried out in the Information System course of the Master Degree in Management Engineering, at the University of Catania. The course was designed at onset following an approach that seamlessly integrates two of the three major trends identified in (Bandara et al., 2010), namely trend 1) and 3); also, it was based on the use of design precedents, following an approach that has been extensively tested in the context of IS courses for Computer Engineering students (Faro and Giordano, 1998), (Giordano, 2004). The course was organized around two main phases: 1) the design phase, with a methodological approach that aims at integrating the process view, the data view and the user view; and 2) the implementation phase, that by adopting a software solution made available on line to the entire community of students allows for a business workflow implementation in which the students are shielded from the details of system installation, configuration and management.

The paper is organized as follows: section 2 presents the teaching context; section 3 details the pedagogical approaches; section 4 presents some comparison of the teaching experience; section 5 draws the conclusions and highlights future work.

2 TEACHING CONTEXT AND CONTENTS

The course is a 6 credits graduate course in Information Systems for the Management Engineering degree, requiring 60 hours of lessons and classroom activities. The students can register in the course after a prerequisite undergraduate course in database design, where they have to complete a project requiring the design of a conceptual model, its implementation in a Relational Database Management System (RDBMS), with the option of prototyping a web interface that exposes the data.

Their only programming experience is with Visual Basic for Application (VBA) to manipulate data inside the Microsoft Access RDBMS. About 60 students enroll each year, with a roughly equal distribution between males and females. The IS master course has been centered traditionally on teaching systems analysis and design methodologies, for business process modeling (Weaver et al., 2002). The first time when business workflow analysis and design was introduced was in the 2007/08 academic year (a.y.) and used Petri net for workflow modeling (Van der Aalst and Van Hee, 2004); in the 2008/09 a.y. the swim lane workflow modeling and the complete design methodology proposed by Sharp and McDermott in (Sharp and McDermott, 2001) were introduced and refined in the 2009/10 academic year as proposed in (Sharp, 2008), where a swim-lane “shows what is done, by whom, in what sequence”. The swim-lane diagram (Figure 1) shows:

- Actors vertically aligned at the beginning of the horizontal line, one actor for each line;
- Tasks, represented as rectangles;
- The flow of actions represented by an arrow from left to right that joins consecutive tasks.

The handoff, represented by an arrow that crosses the swim-lines of two actors.

Figure 1: An example of a swim-lane involving two actors performing two tasks with an handoff.

The swim-lane allows to represent constructs such as sequence, collaborative task, choice, parallel flow, conditional parallel flow, temporal constraints.

In all the three editions of the course the objectives, with particular emphasis on the workflow modeling part, were:

- Acquire the basic techniques and skills for business process and workflow modeling with the ability to work out the scope of each technique, as well as its strengths and drawbacks.
- Acquire the capacity to use and to program workflow modeling and management tools.

Complementary objectives were the development of critical thinking skills, capability to analyze problems from different perspectives, draw conclusions and apply these conclusions in the design phase; as well as improving communication and collaboration skills.

The lessons typically started with a presentation of the key concepts, concepts to be applied as soon as possible in a case study during interactive sessions, where the solution was often reached with the intervention of all the students with the teacher and tutor mostly involved in a facilitator role, with a recap phase at the end of the design activity. The interactivity was simply managed by posing a question, even complex ones such as "design a system capable of …", and then let the students work alone or in group during class activities. After a reasonable amount of time the instructor asked to the students to volunteer for presenting their solution. The solution was discussed in class by letting the students, in turn, ask questions, propose different designs, compare different solutions and so on. Each class ended with small assignment meant as a reinforcement activity requiring a practical application of the main concepts and methodology exposed during class. Examples of these small assignments are: designing from a use case schema the E/R model, correcting a swim line, designing a swim line, correcting and designing an E/R schema and so on. The small assignments were deliberately not graded but critically discussed in class. The choice of no grading policy was meant to increase the students' confidence and lower the fear in public intervention. The syllabus of the project for the 2007/08 (a.y.) is presented in Table 1. Particular emphasis was given to the workflow design and workflow pattern using Petri Nets. During the course it was requested to the student to read journal and conference paper such as (Hammer, 1990) and (Russell, 2006). The syllabus of the course for the 2008/09 (a.y.) is presented in Table 2.

Table 1: Course syllabus for the 1st edition of the course.

Topic	N. hours
Business Process reengineering	2
The five level of analysis: mission; strategy and goal; Business Process; Presentation; application logic	1
Reference model: Set of definitions to describe the knowledge domain.	1
Petri Net	6
Petri Net extension: color, time, hierarchical	2
Workflow representation using Petri Net	4
Workflow patterns	4
Total	**20**

Table 2: Course syllabus for the Workflow modeling in the 2nd edition of the course (including implementation).

Topic	N. hours
Business Process reengineering	2
The five levels of analysis: mission; strategy and goal; Business Process; Presentation; application logic	1
Workflow modeling (business process modeling)	6
Use case and use case scenario (presentation)	2
Transaction modeling (application logic)	2
Entity model (data model)	2
Process identification	2
Initial evaluation and metrics	2
Synthesis poster	2
Tour of Share Point Portal Server and Share Point designer	1
Application and site creation. User and groups	1
List and Document library. Web Pages and Web Part available in SharePoint Designer.	1
Workflow: conditions and actions available in Share Point Designer	2
InfoPath and form design	2
Visual Studio .Net. Workflow Testing	2
Total	**30**

The Synthesis Poster, according to (Sharp and McDermott, 2008), “takes the main elements of framing the process – the process scope and contents, and the case for action, vision, and differentiator – and puts them on a single piece of paper. In the 2009/10 academic year the set of design tools were incremented with dynamic data behavior by the Entity Life History.

The workflow was implemented and deployed using Share Point. In the first edition of the course some minor attention was given to the installation and configuration of Microsoft Share Point, attention that was completely eliminated in the subsequent editions of the course by giving to the students either an on-line system or a pre-installed and configured virtual machine. Share Point was also used for visualizing OLAP cube in the second module of the course were data-warehousing was treated.

Share Point Portal server was chosen after a review of the available collaboration and workflow suites due to: its tight integration with the Microsoft Office suite, that is the most used set of tools used in the industry by business manager; its simple usage powered by the availability of out of the box tools to perform a vast set of operations with no need to develop code; its great flexibility in developing powerful workflows by designing and coding within the Visual Studio .Net framework.

The tight integration with the Excel spreadsheet using the Excel Services, as well as the possibility to synchronize data with Relational Database Management Systems (RDBMS) such as Microsoft Access and Microsoft SQL Server allows the students to implement and integrate quite easily the design project developed using the methodology.

The availability of a rich set of conditions and actions in Share Point, even richer in Web-site design tools (Share Point Designer) used in the course, as well as third part components (e.g. for (D'Urso et al., 2009), allow for a fast prototyping with no or minimal coding intervention in most cases. In this way students cognitive effort can focus on the design activity that is at the core of the course.

At the end of the course lessons the students had to develop a project requiring to model the business processes of a real or simulated Small Medium Enterprise operating in the local area. Many projects, however, were based on existing small/medium enterprises and students designed the existing “as is” scenario and proposed possible improvements through the “to be” scenario.

In the project the student had to follow the methodological approach sketched in Figure 2 (Sharp and McDermott, 2001) and (Sharp and McDermott, 2008), using the design tools mentioned above, i.e., the project data model, use cases, an use case scenario, transactions and process metrics with detailed specific of the enterprise Information System.

The students had also to produce a working prototype of the project developed with Share Point portal server. The project was not the only element to make up the final grading of the course, which was based on the assessment of three assignments:

1) Quality and usability analysis of an enterprise web site (20%)
2) Written test with open questions concerning the theoretical aspects of the course (40 %)
3) Project regarding the complete workflow analysis of a small/medium enterprise, including a working prototype of the project developed with Share Point portal server (40 %).

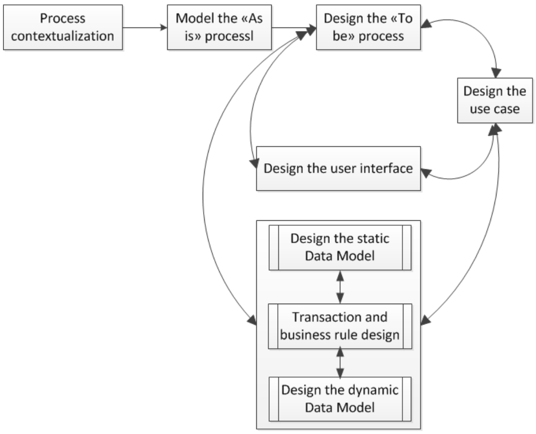

Figure 2: The BPM methodological approach used for the project.

The model prototype had to be implemented using Microsoft Share Point with a tight integration with databases such as Access or Microsoft SQL Server and spreadsheets such as Excel.

The project was considered as a capstone to apply the design methodologies in a real world scenario, improving creative thinking while developing better solutions for the “to be” process, critical thinking while comparing solutions from peers; improving communications skills (verbal and written), and collaboration skills during teamwork.

The typical number of team members was three, allowing for a good deal of interaction and point of views, yet avoiding overcrowded groups that hinder tasks and responsibility allocation and often lead to a lesser engagement by some members of the team.

Tasks and responsibilities were self-allocated by the students and verified by the tutor.

It was stipulated that in the final presentation of the project, discussion of the various aspects of the project from the team members was randomly chosen despite the original work subdivision. In this manner all the team members have to know all the details of the whole project. Along the years, the business domains have been ranging from insurance companies, to laboratories for clinical analysis, to banking, to photovoltaic panels production on demand, to car workshops, to tour agencies, to an international food industry and so on.

The tutoring activity was quite demanding, requiring consultation both on a variegated set of application domains and on some implementation and deployment details. Figure 3 represents a disciplined way of thinking about the tutoring support activity, using the graphical notation of the horizontal swim lanes adopted in the course. The key interactions among the main actors are highlighted as well as the most relevant aspects in the tutoring process.

The project presentation, performed by the tutor, is concerned with highlighting the main goals of the final project, the grading policy and some project management issues. Then the teams freely choose the application domain of their work also by consulting a shared pool of former projects, as in (Giordano, 2004). The student are also required to peer review one project of their colleagues. The first year that the business workflow was introduced in the course, given the discontinuity with the former methodology, the support that could be obtained from the pool of previous projects was limited to getting a sense of the complexity of the various business domains and to seeing instances of the applications of use cases and E/R modelling, whereas the actual workflow and business processes were "hidden" in the Data Flow Diagrams, instead of being explicit in swim-lanes. In the third year of the course, the "shared memory" of the course provided a more stable and comprehensive resources pool reflecting the consolidation of the methodology adopted for BPM.

At the end of this consultation phase the team produces a project proposal that is evaluated by the tutor. If approved, the team starts working on the project and submits project milestones to the tutor, who reviews the milestones following a guided inquiry process. Meetings with the tutor are scheduled upon teams' request.

The process ends with the final deliverable preparation, where students produce the entire design, highlighting each major decision taken and explaining the reasons behind the decision, possibly comparing two or more different approaches to the same problem. After the final deliverable is approved by the tutor the project is presented and discussed, together with the working prototype, in the final presentation in front of the teacher and the tutor.

The workflow schema in Figure 2 can help in a

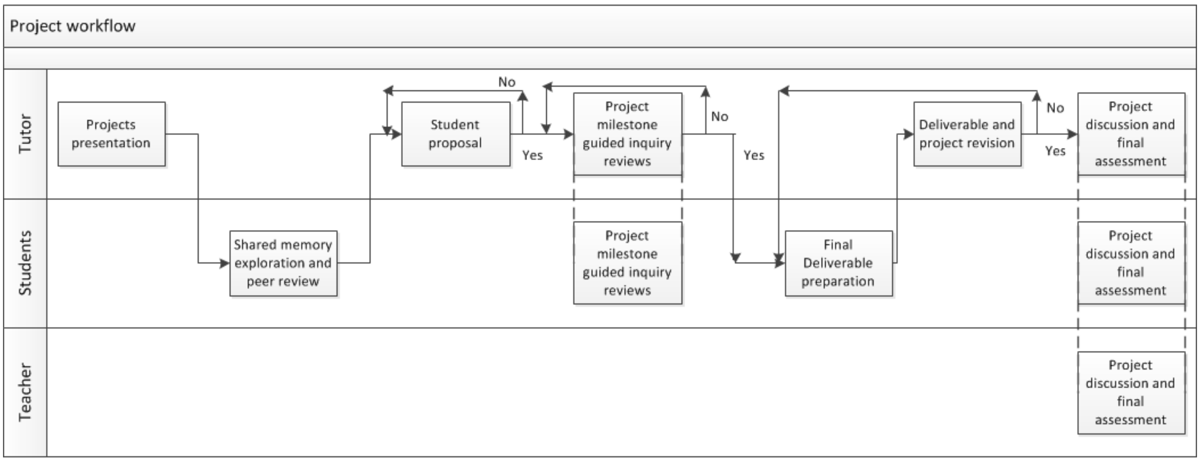

Figure 3: Project management workflow.

better management of the whole project development phase, by offering a clear view of all the phases and progresses, and thus facilitating the communication among all the actors involved, namely students, tutor and professor, also through documents exchange.

Work can be found in literature describing the advantage of using a collaborative system, such as Share Point, to improve interaction among teacher, tutor and students such as (Rockinson-Szapkiw, 2011) or to improve content management (Tallapragada et al., 2012).

The project required 4 to 6 weeks work for completion after the end of classes.

3 PEDAGOGICAL HIGHLIGHTS

The main pedagogical approaches and instructional strategies followed during the course are the following:

1) Use and sharing of previous projects and experience: students used and reviewed the projects from the previous academic years in a "shared memory" fashion (Giordano, 2004). Projects are shared without the final teacher feedback, thus encouraging critical analysis.
2) Using interactive lesson focused on reviewing cases, and on in class collaborative analysis and design of a solution for small practical cases;
3) A guided inquiry style of interaction, both in class and in the tutoring sessions during project development;
4) Video screen recordings of the technical implementation procedure inside the Share Point portal server.

Especially during the tutoring and reviewing sessions, care was taken to avoid both a "no intervention" approach and a "solution offering" approach.

The teacher, in the role of facilitator of knowledge building, especially with the most brilliant students, answered the questions with further questioning, and in general, guided the students to discovering the solution, by offering practical small exercises as guidance to solving the problem, by suggesting to reviewing study materials and so on.

4 CRITICAL COMPARISON AND LESSONS LEARNT

The overall appreciation of the course was good as pointed out from student active participation in the lessons, effort put in the projects and answers to informal questions such as “what have you learned during the course?” The performance of the students in terms of grades was overall steady, more biased in the direction of higher grades, despite the increasing load in terms of concepts and competences they had to grasp.

In general, allowing the students to be immersed in a real world scenario, focusing on real problems, communicating and collaborating with the local enterprise domain expert and so on, was a definitive pro in the course.

We also agree with (Rockinson-Szapkiw, 2011) that, especially for older students with a more comprehensive background and better reasoning skills, allowing them to choose the domain of application of the business process modeling methodology, or the "surface agenda", tied with their personal story, background and interests, greatly improves student involvement and participation in the project.

In this way the teachers and the tutor maintain the responsibility in choosing the methodologies, leaving the students to apply it in their preferred domain.

In particular, concerning an overall assessment of the quality of learning and of the efficiency of the pedagogical strategies adopted, taking into account the changes in methodology introduced in the three years, it is worth remarking the following points.

- Use of a complete design methodology such as the Sharp and McDermott one has several advantages compared with the usage of a single design tool such as Petri Nets. A comparison of the students usage of swim lane and Petri Nets design tool for workflow modeling, based on the frequency of requested tutoring interventions and on observing the speed by which the student were able to sketch a workflow on the fly in front of the tutor seem to suggest a steeper learning curve for Petri Nets. One of the reasons why swim lanes, and in particular the horizontal swim lanes proposed in the methodology could be easier to learn could be found in the visual span asymmetry (McConkie and Rayner, 1975; Pollatsek et al., 1981): for readers from left to right a visual span asymmetry consisting of 3-4 characters to the left of fixation vs.14-15 characters to right of fixation has been demonstrated. The swim lanes organization in different levels allows for an easier top-down design approach focusing in the overall process in the first level and increasing the detail in the second and third level. Overall, swim-lanes are more suited for a managerial environment; Petri Net are, of course, more suited for formal proof of correctness or synchronization.
- Using a complete methodology and a plurality of design tools and representations allows, in general, for a deeper understanding of the problem at hand resulting in a better analysis and design that take advantage from the interrelationship among the design tools (Giordano, 2002), which provides means for cross-verification and improvements of the design artifact under development. From a pedagogical standpoint it is a best practice to present as earlier as possible the application of all the needed design tools, starting from a small project and incrementally enlarging it step by step in order to let the student to deeply understand, integrate and use all the design methodologies. However, some limitations to the efficacy of self-correction of the methodology through cross-verification can be noted, as exemplified in the type of errors detected in the students projects, listed below.
- The most common errors detected in the students' deliverables are the following:

a) Incomplete swim lane because of missing handoff. The most relevant cases are: a) not informing the client of a decision, and b) incomplete management of the revision cycle of a document or a production phase

b) E/R diagram errors, especially concerning the correct usage of the association entity and how to associate an item in a N-N association with other entities;

c) Inconsistency between different design models, e.g., information present in the use case scenario and missing in the E/R diagram; inconsistency between the ELH and the swim lane, such as a missing event in the ELH, presence of an irrelevant event in the ELH, inconsistency between use case scenario and swim lane;

d) Incorrect identification of the critical success factors in business process modeling, and in particular, confusing process and product metrics.

The above type of errors, on the one hand, point to the aspects that deserve special attention and reiteration in communicating with the students during the in-class and tutoring interactions; on the other hand, they reflect the fact that the efficacy of any analysis and design methodology as a self-correcting instrument, can be affected by limited knowledge or practice with more advanced data modeling concepts and by the higher cognitive load involved in coordinating representations dealing with temporal aspects of processes and entities, respectively.

- The use of the shared pool of previous projects, increased the quality of the final deliverable over time, especially in the last observed year. The shared projects database can be used to evaluate the didactic experience and objectively measure student improvements. This is in line with the approach adopted in (Giordano, 2002) and, more recently, in (Paul, 2012) and (Tenenberg and Mccartney, 2008) where the authors suggest to look systematically at students' artifact to derive data that can provide insights into questions about learning. From a preliminary analysis of the student projects over the years we can observe:

- Increased complexity of the analysis and the design, as measured by the number of processes, actors, and steps in the processes in the swim lanes, and by the number of entities and association entities in the E/R diagram
- Increased degree of associations between the platform (Share Point Portal Server) and the underlying databases.

Table III shows some aggregate measures of these improvements between the 2008/09 and the 2009/10 academic years, computed on a random sample of 5 projects from each year cohort. The table reports the average percentage of improvement, if positive, for the 09/10 academic year over the previous one.

This preliminary data suggest an overall increase of the complexity of the analyzed process in the last year: a larger number of swim lanes both at the handoff level (Level 1) and the Milestone level (Level 2); a greater number of steps performed by less actors, increased number of tables, a smaller number of use cases explained in more detail, as indicated by the increase in use case scenarios, an increased number of transactions and an increased number of steps implemented in SharePoint.

Use case scenario, according to (Hamer et al., 2008) “depicts the dialogue between an actor and a system for a particular scenario”.

The observed increase in overall design complexity, although based on a limited sampling aimed at preliminary exploration of the data, is in line with the effect of "organizational learning" discussed in (Giordano, 2002) and (Giordano, 2004) when a shared memory of design artifacts is in place.

Concerning the technological challenge of setting up a relatively complex environment, prior installation of a virtual machine was made available on line and also distributed using a DVD upon students' request.

This allowed to eliminate all the steps required for software installation (operating system, Microsoft Office, Microsoft SQL server and Microsoft Share Point Portal Server) and configuration, and all students could working on the same initial configuration, thus facilitating debugging.

Screen video recordings greatly reduced the tutoring burden over implementation issues, allowing the teacher, tutor and students to focus on the design phase, since the students to perform the practical operations at their own pace and resolve most of the technical problem by themselves.

Table3: Comparison of two academic years projects cohorts: average number of handoff swim-lanes (L1), average number of milestone swim lanes (L2), average number of actors (A), steps (S), tables (T), use cases (UC), use case scenario (UCS), transactions (T) and Microsoft Share Point steps (SPS).

Year	L1	L2	#A	# S	#T	# UC	# UCS	#T	# SPS
09/10	3,0	0,6	5,5	20,7	10,8	5,4	3,6	8,6	7,2
08/09	2,0	0,4	6,4	13,0	10,2	7,8	0,2	3,8	4,8
Increase (%)	**5**	**50**	**-14**	**60**	**6**	**-31**	**n.a.**	**1**	**50**

5 CONCLUDING REMARKS

In this work we described a three-year teaching experience in an Information System master course for Management Engineering students, with a focus on business process modeling.

The shift from workflow analysis and design using Petri Nets to a comprehensive methodology where Business Processes are modeled according to swim lanes affords several advantages. Technical aspects related to process implementation in a commercial software suite could be tackled by decreasing the implementation and deployment detail as much as possible.

As a further study we plan a more thorough comparison of the different approaches and methodologies that we have field-tested, by adapting the analytical evaluation grid provided in (Giordano, 2002) to include swim-lanes and process metrics, and applying it to analyze larger samples from the available cohorts of project artifacts.

This analysis will involve relating any detected misconceptions to evidence on how the students have coordinated the various analysis and design notations and to any common feature of the modeled enterprise/business domain.

The observed increase in overall design complexity, although based on a limited sampling aimed at preliminary exploration of the data, is in line with the effect of "organizational learning" discussed in (Giordano, 2002, 2004, 2009) when a shared memory of design artifacts is in place to reuse past experience.

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Fun in CS2*

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Keywords: Data Structures, Algorithms, Computer Game, Computer Game's Player, Programming.

Abstract: We report our experience of including the implementation of a player of a computer game as a programming project in a CS2 course focusing in data structures and algorithms. Every semester, an instructor designs the rules of a game, prepares its visualization, and implements an elementary player with a very simple strategy. The game is then delivered to students who, as a first step in order to pass the project, must program a player that wins the elementary player. Then, a tournament begins among all the students with accepted players. At every round of this tournament a player is eliminated until just one player, the champion, survives. Grades for this assignment are computed automatically and increasingly with respect to the round where students have been eliminated. The result is a fun and very motivating programming experience for our students.

1 INTRODUCTION

As professors of algorithmic subjects, we face nowadays that, frequently, our students are poorly motivated by our class matters but pretty hooked to computer games. So, following the saying *"If the mountain will not come to Muhammad, then Muhammad must go to the mountain"*, we have decided to introduce computer games in our data structures and algorithms courses.

We have done so by means of a programming activity consisting in the implementation of a strategy for a player of a computer game. The goal is that the programming of this player should involve the implementation of some of the algorithms and data structures taught during the course, and to motivate for the self study of others.

Here, to program a player consists in designing strategies to move some tokens, having complete information of the map in which the tokens are lying and about the rest of the players. In fact, each player controls a set of configurations that will interact with the game by reading information about the game world and inform of its moves to interact with it at each turn.

Note that games are meant to be played by programs, and to be seen by humans. There is no human interaction during the games. The program to control the intelligence of a player is written before each match starts.

The program submitted by a student (a player) will be faced to the programs submitted by other students, and will get better or worse score depending on the way it is planned, i.e., how good is in practice its programmed strategy. Unlike most exercises of the course, this project is open: it is not about solving a specific problem, but to prepare a strategy, to study the strategies of the opponent players, and, if required, adjust or reprogram the own strategy.

The idea was inspired by the ICPC-Challenges organized by ACM during the World Finals of their annual ACM International Collegiate Programming Contest[2]. A similar initiative is the AI Challenge[3].

The performance of this lab assignment encourages, among other skills, algorithmic programming aspects (implementing their own strategy), programming related to artificial intelligence (controlling the heuristics of the agents that appear in the game) and even good programming habits, because the players are expected to change over the project duration to adapt to their peers' strategies, and thus, the students with the most flexible and maintainable code will be benefited.

There are several other initiatives that include automatic evaluation and assessment systems, digital and web support, competitive and problem oriented

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[2] See http://icpc.baylor.edu.

[3] See http://aichallenge.org.

learning, among others (Giménez et al., 2012; Douce et al., 2005; Saikkonen et al., 2001; Joy et al., 2005; Cheang et al., 2003; Kosowski et al., 2007; Kurnia et al., 2001; Revilla et al., 2008). But, as we will show, thanks to the enthusiasm that video games rouse amongst students, the experience presented in this paper is particularly engaging.

2 CONTEXT AND GOALS

This project is included as part of the "Data Structures and Algorithms" course of the Facultat d'Informàtica de Barcelona and the "Algorithmics" course at the Facultat de Matemàtiques i Estadística (both at the Universitat Politècnica de Catalunya). These courses (with minor differences between them) start by introducing the concepts of algorithm analysis, together with the required basic mathematical tools. Then, these bases are used to study and analyze various implementations of classic and essential algorithms and data structures (sorting and searching, divide and conquer, dynamic programming, hashing, balanced binary trees, graph traversal, shortest paths, among others).

These courses intend to combine basic theoretical aspects of algorithm design and analysis together with several programming features. They consist of 6 ECTS[4] that involve two hours of theory classes, one hour of classes of problems and one hour of laboratory classes per week.

Inside such courses, the educational objectives of the game are the following:

- To provide an original and motivating environment to facilitate the integration of generic and technical skills.
- To supply an active learning activity that improves the learning of programming, data structures and algorithms.
- To encourage the development of competencies such as the design and analysis of effective, efficient, collaborative and/or competitive strategies to obtain well-defined objectives.
- To introduce didactic materials in new formats using new technologies (web, social networks, forum, graphics, etc.).
- To promote the programming and the design of efficient algorithms, improving the integration of practical and theoretical learning.
- To offer tools that allow students to strengthen competencies such as the gradual and continuous improvement and/or overcoming of previous work at both personal and social levels.
- To promote new evaluation mechanisms for the skills of programming and design of efficient algorithms.

3 DEVELOPMENT

The development of this activity has five main phases: preparation, distribution, qualification, tournament, and grading.

Preparation. A new game is created by one or more instructors of the course; some actual games are presented later, in Section 4. A game consists of the following elements:

- The *documentation* gives a basic overview of the game, describes its goals and rules, and presents a tutorial on how to use it.
- The *interface* of the game is the C++ API that users will use to write their own strategies. It basically includes functions to query the current state of the board and functions to order changes to the agents in the board.
- The *implementation* of the game includes all necessary coding to make the game work, such as reading the initial boards, handling the rules, updating the score, etc. It also includes the *viewer* of the game, that is, the tool that will be used to see games in a graphical way. For portability reasons, this viewer is programmed in Javascript.
- An elementary player called *the dummy*, which implements a fairly simple game strategy.

Distribution. All the above elements (including the source files) are given to the students, with the exception of the dummy player, for which only the object files are distributed. With this material, all students can design, implement, run, debug and view their own games at home as often as needed. In addition, students are given access to an online web server that will handle their submissions and games.

Moreover, we try to motivate students as much as possible by designing advertisement posters of the game. We hang them on the walls of classrooms and campus squares.

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[4] ECTS stands for European Credit Transfer System, which is a standard unit for comparing the study attainment of students of higher education across the European Union. One academic year corresponds to 60 ECTS-credits that are equivalent to 1500–1800 hours of study, i.e., 25–30 hours of study per credit.

Qualification. After distribution, students are given three weeks to work on their own designing a strategy and writing a program for their players. The only requirement for their players to qualify is to consistently beat the dummy player. This requirement is necessary to ensure that a minimal coding effort is done by each student; otherwise even an empty strategy would qualify. In order to prove that they beat the dummy player, students submit their programs to our online judge, which checks that in four random games against dummy players, the submitted player always wins. Students have an unlimited number of opportunities to beat the dummy player within the three weeks deadline.

Tournament and Grand Final. The most exciting phase of the game consists in the play-off tournament, which starts after the previous deadline with all the qualified players. Over a couple of weeks, the game's website automatically takes care of the tournament, handling matches among subgroups of students (typically four) and performing the necessary rounds to give a ranking to all the players by successively eliminating the "worst player" of each round. All the games and results disputed during the tournament are publicly visible in the game website.

From round to round, students may still submit new strategies that will replace their formers ones, in order to try to react to the actions of their mates. These replacement players must, of course, also beat the dummy.

When only a few (16, say) players stand, a grand final is organized in the conference room of the Facultat d'Informàtica de Barcelona to discover the final champion. The surviving players are grouped into semi-finals, and the winners of each semi-final dispute the last round, where only one of them survives. During the ceremony, the programmers of these best players are invited to give a public short speech explaining how their players work and how they are programmed.

Grading. The total grade for our courses is a number between 0 (nothing) and 10 (perfect). Out of these 10 points, 9 come from standard evaluation systems (tests, exams, lab assignments). Then, all the students who beat the dummy before the deadline obtain one point. In addition, and according to their final ranking in the tournament, each student receives up to an extra point to be added to his final grade (for a maximum of 10, of course). This is computed proportionally to the time their player is still in the game, thus the first eliminated player gets no extra point while the champion gets one extra point.

4 ACTUAL GAMES

Over the past few semesters, we have created several games, trying our best to get attractive and enjoyable activities. All the games feature a board where several agents controlled by four different players interact for several rounds to get a final score. See Figure 1 for some examples.

PacMan. This is an adaptation of the classical arcade game for four players, where each player controls his own pacman and three or four ghosts. Normal pills eaten by pacmen score points, and power pills temporally boost pacmen to move faster and to eat ghosts, in order to get extra points and weaken adversaries.

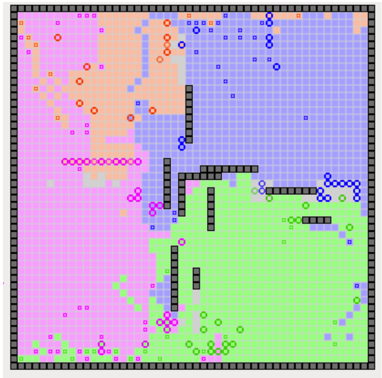
Battle Royale. Each player controls several knights and peasants. As they move to adjacent cells, peasants colonize cells. Knights capture (kill) adversary peasants to convert them to their team and probabilistically fight adversary knights. For each player, the score is the final number of colonized cells. The name of the game comes from the famous Japanese cult film, just for the large number of kills during each game.

Apocalypse Now. In this adaptation of the Vietnam war film, the goal of each player is to control as many check points as possible. To do so, each player can use soldiers, helicopters and parachutists, who have different mobility attributes depending on the terrain they move (jungle, field, water or mountain) and have different kinds of attack (body to body or napalm).

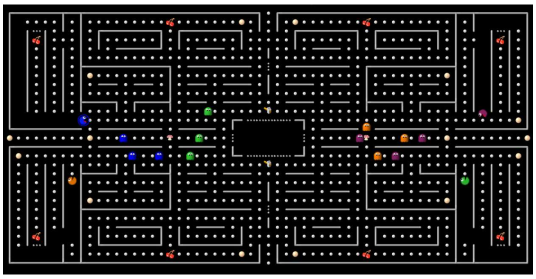
Tron. This is a variation of the classic game and film where each player controls four light cycles that should not crash with the prefixed walls in the maze nor with trails of light that all light cycles leave behind. In case of a crash, the light cycle and its trail disappear from the board. The winner is the last player that survives.

Dragon Ball. Inspired by the famous animated series, in this game each player must control Son Goku in his quest to collect dragon balls and bring them to hoi-poi capsules. In the process, players can launch kame hame attacks to other players and use kinton clouds to move faster.

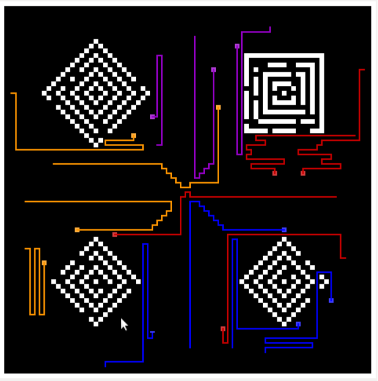
In all the games, the board is organized as a collection of cells that induce a graph. At each round, the movements of the agents are governed by each player strategy and invoked through the game API. Each player decides its movements for the next round independently of the other players, and there is a randomization process by which possible collisions are resolved.



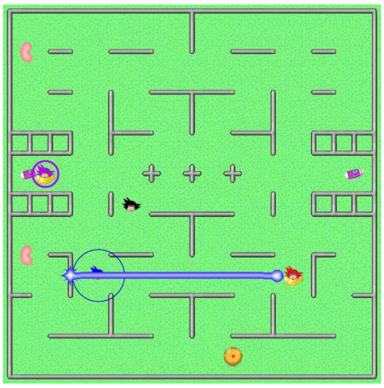
Battle Royale



PacMan



Tron



Dragon Ball

Figure 1: View of some games.

5 THE ONLINE SYSTEM

Students use a website to submit their solutions, check whether their programs beat or not the dummy, request training games with other players (so that they do not need to exchange their source code to play games among them) and track the results of the tournament games, which presumably determines the quality of their programs. This website is largely independent of the game, so is reused each semester.

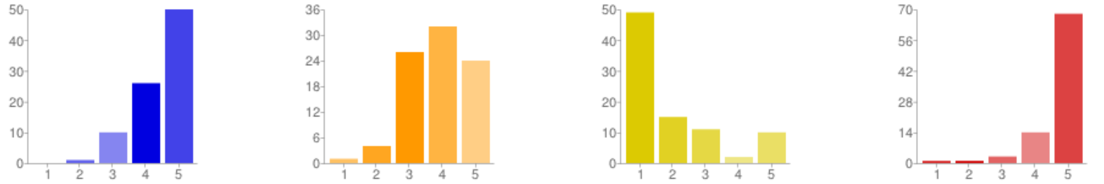
To dispute the games, our system uses the facilities of the Jutge.org infrastructure, which is an educative online programming judge developed at our University and open to all users (Giménez et al., 2012). In brief, Jutge.org offers a highly scalable and secure system that processes submissions to programming assignments and offers a verdict on their behavior.

The techniques to dispute our types of games must however extend the security measures used in similar online judges (Forišek, 2006), because not only they must prevent players to abuse or tamper the system, but they also must prevent to cheat other players. To do so, our system disputes the games by confining each player to its own process with its own user. Moreover, there is an additional process that mediates in their communication (to check that they obey the rules of the game) and supervises the player processes (to check that none exceeds memory or time limits and to handle this case if needed).

While these levels of security can seem paranoid at first, they are rather necessary, as some students are able to devise contrived ways to try to cheat. For instance, during the last semester, a group of students has used knowledge on the way that the parameters are pushed on the stack of function calls to locate the memory positions that encode the walls of the maze, and so could change them to their advantage. While this hack worked with the distribution of code we give to students and could amaze (or even terrify) some of their opponents, it did not have any consequences inside the server that plays the official tournament thanks to not sharing the memory space.

In addition, our system interacts with the well-known JPlag service to detect (and specially discourage) plagiarism (Prechelt et al., 2007). This could be an important issue (it is not), because none of the submitted programs will normally be read.

As an example of the magnitude of the tournaments, in the semester PacMan was played, we had 143 students that submitted 2929 programs, 749 of them beating the dummy player. A total number of 7761 games were disputed and 2.2 GB of data storage was needed.

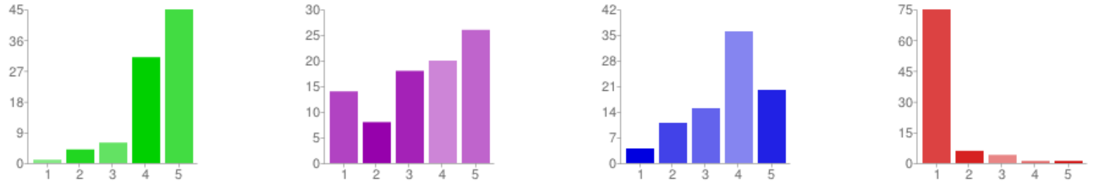


I liked the game.

It was easy to beat the dummy player.

I would rather spend my time studying theory than programming my player.

To program a player is much more motivating to me than traditional programming projects.



Competing against my classmates in the game motivates me.

I have taken the time to improve my player after winning the dummy player.

The documentation of the game is right to me.

I would rather prefer this course without game.

Figure 2: Results of the survey for the PacMan game (1: Strongly disagree → 5: Strongly agree). Values are in percentages.

6 SUPPORT

It may be clear now that, besides the investment of building an online system to process submissions, the development of this activity repeatedly calls for some effort of the course instructors.

This support starts at the preparation phase (we estimate that this involves about 40 hours of work), continues monitoring the game and reacting in the case of need (we estimate this involves about 10 hours of work) and finishes preparing the grand final.

Indeed, as most participants and many of their classmates look forward to the grand final of the game, this is an important event that is well prepared in advance: slides, game matches, videos, viewers, etc. The final is attended by many students and faculty staff. It is worth commenting also that in order to increase the students excitement and expectation about the grand final, we design a new visual interface (as attractive as possible) together with a stylish soundtrack. A video recording the grand final of the Battle Royale game can be found at http://media.fib.upc.edu/fibtv/streamingmedia/view/2/209. At the moment, this is the video with most views among all videos posted in our computer science school.

In addition, one has also to add up the time to give support to the students that request help from their instructors. Some of them require individual or group office hours.

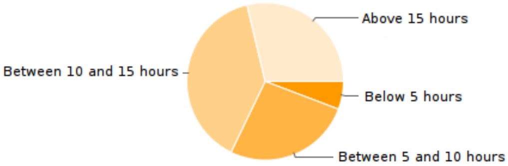


Figure 3: Results for the question *Time I have spent working on my player*.

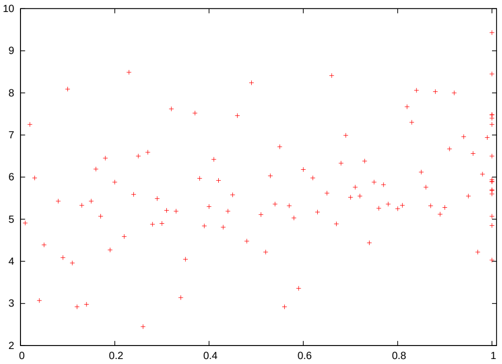


Figure 4: Scatter plot of final grade (from 2 to 10) according to rank in the PacMan tournament (from 0 [worst] to 1 [best]).

7 RESULTS

The game activity has been implemented as described in the latest five semesters. It got a large percentage of participation (always more than 90%) and almost all students who tried it could enter a player into the tournament, i.e., their player could win the dummy and therefore, they passed the project. Moreover, since to keep alive during the tournament provides extra points for the course's grade, this activity really helps several students to pass the course (about a 20% of students pass the whole course because of this extra point).

In order to support these statements, last semester we applied a survey to our students. Figures 2 and 3 show the results of each of the issues on which we consulted students. The range of answers was from 1 (strongly disagree) to 5 (strongly agree). From the surveys, we can infer that almost all students enjoy the game activity, that they do not find too many problems in beating the dummy player, and that they prefer it to more standard assignments. Also, they like to compete against each other. Therefore, we have corroborated that presenting the project as a game has had a great impact on teaching. Moreover, this practice model is very attractive and motivating to our students.

On the other hand, one could think about some correlation between the ranking of the students in the tournament and their final grades in the course. Figure 4 shows this information, and the Spearman's rank correlation concludes that although the correlation is weak (Rho $= 0.38$), the correlation is statistically significant (p-value $= 2.757e-05$).

As said, during the grand final, the programmers of the best players explain their strategies. According to their explanations, in a few cases it is possible to reach the grand final with just a very simple player, but in general, winners implement smart and complicated strategies, with sophisticated algorithms.

8 DISCUSSION

Along this work we have described our experience introducing programming computer strategies for computer games into typical CS2 courses. We have shown evidence on how this kind of programming activity is fun and highly motivating to computer science and mathematics students. This motivation also encourages professors, and thus facilitates a pleasant working environment.

As a weak point of such a project, one can think that students seem to be so hooked that they spend more than the recommended hours to program and improve their players, and this in detriment of the hours they should dedicate to other parts of the course and to other courses. But, when surveyed about this issue, they did claim that they dedicated a big amount of time and work, but that this was mostly in their free personal time, which otherwise they would not have dedicated to study.

Overall, we consider it such a successful experience that we want to continue improving and spreading. Among the ideas we have to go further, it is worth mentioning that the games we have created so far are very competitive. So, in the future we would also like to develop collaborative games in which players should help each other in some way. On the other hand, we want to extend our online system to offer these games to the general public. A systematization of the website and of the design process of new games is under current development.

ACKNOWLEDGEMENTS

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Research on Automatic Assessment of Transferable Skills

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Keywords: Computer Assisted Assessment (CAA), Automatic Assessment (AA), User Behavior Modeling, Soft Sensor, Rule Matching.

Abstract: Automatic Assessment is an important research subject in Computer Assisted Assessment. However, for transferable skills, which have become important talent criteria in the talent standard of modern service industry and higher education, there are few universal and effective automatic assessment methods. In order to improve the efficiency of the assessment of transferable skills, and provide methodology foundation for automatic assessment of transferable skills, this paper combines the automatic assessment methods based on operation result and operation sequence, and proposes an automatic assessment method for transferable skills. This method includes four parts: definition of user behavior model, collection mechanism of user operation sequence, rule matching algorithm, and weighted score summary. In addition, this paper introduces an instantiated application in a virtual simulation environment to evaluate the proposed method.

1 INTRODUCTION

Assessment is a very important link in the teaching process. It can provide an intuitional way for the teachers and students to know the teaching process, and provide feedback for teaching and learning as well. As is known, assessment is a repetitive work, can be defined accurately, and has strong timeliness. Moreover, sometimes people may not be the best valuator, because they may have different understanding of the same subjective item. In this case, Computer Assisted Assessment (CAA) has become a hot topic in the field of computer supported education, because it has advantages such as high efficiency and timely feedback, and it is almost unlimited in users' time and region.

At present, in the research field of CAA, automatic assessment (AA) of personal knowledge and some professional skills has well-developed theories, methods and technologies. Especially in IT skills, there are a large number of relatively mature systems, covering many aspects of the basic IT skills assessment, including programming languages, such as Java (e.g. RoboCode (O'Kelly and Gibson, 2006)), C/C++, VHDL (e.g. CTPracticals (Gutiérrez et al., 2010)), and operating system application skills, such as Linux (e.g. Linuxgym (Solomon et al., 2006)). These systems can be roughly divided into two categories: 1) AA systems for programming competitions and 2) AA systems for (introductory) programming education (Ihantola et al., 2010). And they are playing a great role in promoting the teaching and learning of IT major.

However, with booming and growing rapidly, modern service industry has changed its talent standards, which means the transferable skills have been paid more attention than professional skills gradually. Transferable skills are skills can be applied either or both: (i) across different cognitive domains or subject areas; (ii) across a variety of social, and in particular employment, situations (Bridges, 1993), such as planning capability, teamwork, interpersonal influence, etc. The assessment of transferable skills is also an important issue in talents cultivation and selection of higher education. However, the assessment still mainly uses artificial ways, and lacks suitable automatic methods. There are two primary reasons: the AA of transferable skills needs appropriate simulation environment; there are great differences between the evaluation standards of transferable skills and standards of knowledge or IT skills, which means the former needs to synthesize users' operation information, operation steps, and operation results to make assessment, instead of simply using the result data as the only standard. In order to improve the efficiency of the transferable skills assessment, and provide methodology foundation for AA of

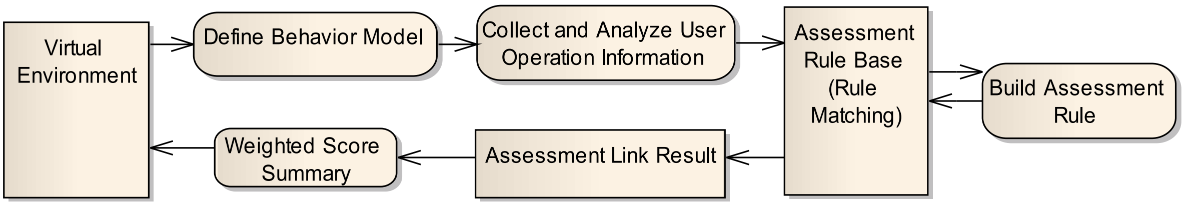

Figure 1: Framework of AA method for transferable skills.

transferable skills, this paper combines the AA methods based on the operation result and operation sequence, and proposes an AA method for the transferable skills. This paper also shows how to apply this method by introducing an application of the method in a virtual simulation environment (SIP).

The AA method of transferable skills is presented in Section 2. The feature of the virtual simulation environment (SIP) and the application of this AA method in SIP are introduced in Section 3. Conclusion and future work are discussed in Section 4.

2 AUTOMATIC ASSESSMENT METHOD OF TRANSFERABLE SKILLS

From point of view of the implementation, AA methods can be roughly divided into two categories: methods based on operation result and methods based on operation sequence, which respectively correspond to the Summative Assessment and Formative Assessment (Harlen and James, 1997). AA methods based on operation result are relatively simple and intuitive, as both the acquisition and assessment of operation result are easy to achieve. Nevertheless, because operation result does not include operation process information of students, the assessment based on operation result is one-sided in a certain degree (Xuan-hua and Ling, 2012). There are few mature AA methods based on operation sequence, and exist following problems: 1) the operation sequence is various in forms and lacks a unified formalization method; 2) user operation is uncertain, so it is difficult to ensure that the operation information collected is valid, which also causes difficulties in analyzing result; 3) the final result of the operation sequence is usually not unique, due to the difference in the timing and repetition of some operations, which makes it difficult to achieve a high accuracy rate in automatic assessment.

In order to achieve a more comprehensive and accurate assessment result, it is necessary to integrate these two methods, that means both the operation result and operation sequence are used as standards for evaluation. Therefore, this paper combined AA methods based on the operation result and operation sequence to propose an automatic assessment method for transferable skills. The method could efficiently solve the problems mentioned in the end of last paragraph. Its process framework is shown in Figure 1, including following four steps: define user behavior model, collect and analyze user operation information, rule matching and weighted score summary.

2.1 Define Behavior Model

In order to describe user behavior in a unified way and make it easier to collect user operation information, this paper defined a user behavior model according to the characteristics of user behavior in simulation environment. This model described the detail information of user operation, including action, operation time, parent node of the current operation, result of the current operation. And in order to make it easily implemented on computer, this model was defined as a four-tuple type E(A,T,P,R):

- A: Action, including operation object and brief event description.
- T: Time, the operation time of the action, including starting and ending time. It is very important to record the operation time, for the assessment of transferable skills is usually related to the completion time.
- P: Parent, the parent event node of the current operation, also called pre-node. There is more than one operation in an assessment link, and they are connected by pre-nodes.
- R: Result, the result caused by the current operation. It can be a piece of result data or change of system state.

This formalized form could record relatively complete user operation information and had good versatility. When applied to certain environment, the

E(A,T,P,R) could be adjusted depending on the simulation environment. Using a serial of associated E, the user operation information would be represented clearly.

2.2 Collect and Analyze User Operation Information

Because the user operation in simulation environment is uncertain, not all user operation information has effective semantic. Traditional methods in user behavior mining (Baglioni et al., 2003) (e.g. web log mining, web usage mining), would gain a lot of useless user operation information, which could not be analyzed before the preprocessing steps such as data cleaning, user identification, session identification and so on. These methods were not suitable for automatic assessment technology, due to high complexity of algorithms. In order to ensure that user operation information collected was effective as far as possible, this paper designed an information collection mechanism, called "Soft Sensor", which meant it was similar to the sensor and could be “inserted” into the simulation environment in right place to collect user operation sequence. “Soft Sensor” was based on the user behavior model E(A,T,P,R), and mainly included three parts: Event Listener, Event Buffer, Event Handler.

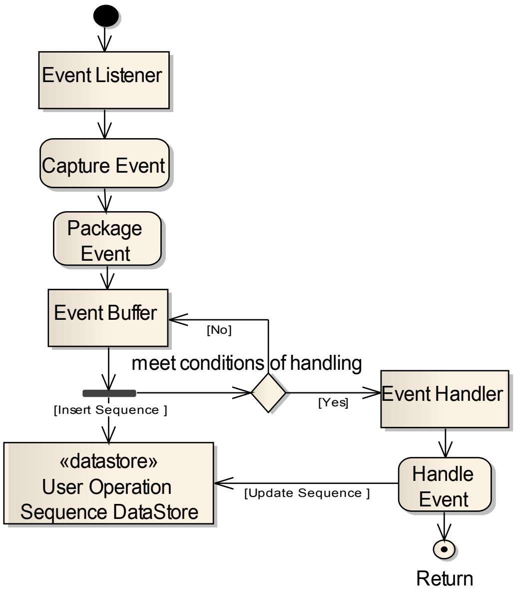

Figure 2: Soft Sensor Workflow

The workflow of “Soft Sensor” is shown as Figure 2. Event Listener was used to capture user operations that were meaningful to transferable skills assessment. The object to which the listener monitored might be a key user operation, system state, or data. When the operation was called or the state/data was changed, the Event Listener would capture this event, and package it into a four-tuple E (A,T,P,R), and sent to the Event Buffer. In the Event Buffer, two things need to be done: insert E(A,T,P,R) into the user operation sequence data store; send those events that meet their processing conditions to the Event Handler, while keeping others waiting in Event Buffer. Depending on the types of operation events, event processing conditions could be defined as three types: immediately, wait for activation (activated by other events), setting time. In Event Handler, the event will return to the original processing operation in system after completing its process flow. Meanwhile, the T(Time) and R(Result) in the event E(A,T,P,R) had probably been changed, so it was necessary to update them in the user operation sequence data store.

2.3 Rule Matching

Due to the difference in the timing and repetition of some operations, the final result of the operation sequence was usually not unique. In order to increase the accuracy of operation sequence assessment, this paper proposed a fuzzy matching algorithm.

An orderly linked list of user operation sequence was generated after the collection and analysis mentioned in Section 2.2. The element of the linked list was the four-tuple E(A,T,P,R), and links between elements were maintained by P(Parent). Before the linked list was processed, a series of standard rules should be established as reference standards for assessment. Inference rules were divided into two kinds, rules based on the operation result and rules based on operation sequence.

Inference rules based on operation result were relative simple: for results of numeral type, corresponding scores could be derived directly compared to reference answers; for results of string type, Levenshtein Distance could be used to calculate evaluation score.

Inference rules based on operation sequence were more complicated. Since operation sequences of different users in the same simulation link might be different in timing or repetition of some operations (e.g. the student failed in a sub-link, and retried several times before success), therefore user operation sequences were diverse. In order to illustrate inference rules based on operation sequence, we defined those indispensable events in one simulation link as “critical node” $E_k(A_k,T,P,R_k)$, and operation sequences made of critical nodes as “critical path”, which could also be considered as reference answer. As the proper operation path of one simulation link might be more than one, the corresponding matching rules should be composed of one or more critical paths as well. Fuzzy matching was used to process user operation sequence, which meant using regular expressions to filter out non-critical node event. For example, one critical path was $E_{k1} \rightarrow E_{k2} \rightarrow \cdots \rightarrow E_{kn}$, and its regular form used for fuzzy matching should be $E_{k1} \rightarrow E_x\{0-N\} \rightarrow E_{k2} \rightarrow E_x\{0-N\} \dots \rightarrow E_{kn}$, in which E_x meant non-critical node and N valued depending on the complexity of simulation event.

The rule matching algorithm for operation information is shown in Figure 3.

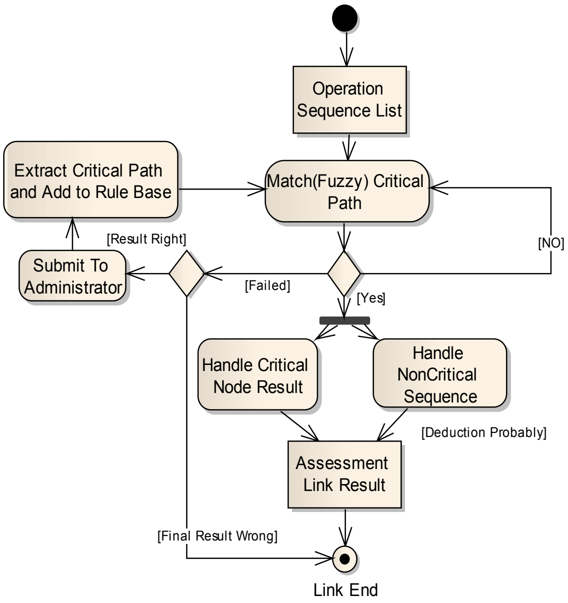

Figure 3: Rule Matching Workflow

1. Use fuzzy matching method to match the user operation sequence list with the critical paths in rule base;
2. Matching successful:
   a) Handle result data of critical nodes using inference rules based on operation result, and send the scores to the assessment link result;
   b) Handle non-critical sequences that are filtered out. Minus scores will be evaluated, according to the time consumption and complexity of the non-critical sequences. That ensures students those spend less time and energy on the non-critical paths to get higher scores.
3. Matching failed:
   a) The result of final critical node is correct:
      i. Submit the user operation sequences to administrator, because it may be correct but does not exist in the current rule base.
      ii. Extract a new critical path from the sequences, and add it into the rule base (by administrator).
      iii. Return to step 1.
   b) The result is not correct, end.

2.4 Weighted Score Summary

It is not comprehensive to evaluate one transferable skill by a single simulation link, because user’s transferable skill may be affected by suitability of simulation environment. Therefore, one skill should be assessed through a serial of related situation, and use the summary of weighted score from each assessment situation.

3 APPLICATION OF AA METHOD OF TRANSFERABLE SKILLS IN SIMULATION PLATFORM

In Section 2, this paper proposed a common AA method for transferable skills, and this method need to rely on a virtual simulation environment. This section introduces an existing virtual internship simulation platform (SIP, Service Industry Perception and Virtual Enterprise Practice), and describes how to apply the AA method into SIP and basically achieve the automatic assessment of transferable skills.

3.1 Brief Introduction of SIP

The SIP platform is a CSCL platform based on virtual business environment, and its major objects are senior undergraduate students. Students participate in the SIP in several teams, and complete the following tasks: team building, founding enterprise, virtual business operation and competition, etc. Thus, on the one hand, this virtual internship can deepen students’ awareness of the modern service industry; on the other hand, it can help students improve their transferable skills, such as teamwork, planning capability, interpersonal communication skill, etc.

The SIP platform has the following features:

1. It is a multi-disciplinary platform, and has low requirements for students’ professional

knowledge, but high requirements for students' transferable skills such as learning ability, planning capability, teamwork and collaboration.

2. It is interesting and attractive to the students, because the SIP is more like a virtual business game than an assignment or test. The students finish their tasks in "non-examination condition", which also means the assessment result has higher reliability.
3. The operation links of the SIP are distinctly separated, and the phased target of each link is also defined clearly.

According to the above characteristics, this paper applied the AA method based on both operation result and operation sequence into the SIP platform, to provide assessment results for the students' transferable.

3.2 AA Method in SIP

This section mainly introduces the implementation of Soft Sensor and Rule Matching in SIP.

The SIP platform was developed using SSI (Spring + Struts + iBATIS), so Soft Sensor was realized by adopting Spring AOP mechanism. The "probe" of Event Listener used the custom java annotation (e.g. @interface SoftSenorListener {String eventID = "";}), thus it could be easily inserted into the code or action that needed to be monitored. A pointcut advisor was implemented to monitor the code which had been appended the annotation "@SoftSensorListener". And a method interceptor was defined to act as the Event Buffer. The Event Handler was a serial of service which implemented the same interface. When the processing conditions were met, the Event Handler would be called by the method interceptor (Event Buffer) using "eventID", which was also the id of corresponding service.

The students play different roles in the SIP platform, and their tasks and transferable skills required in each link are also different. Therefore, this paper chose a typical role – the team leader (also called "CEO" in virtual enterprise) as the assessment object to expound the application of AA method in SIP.

The "CEO" in the SIP platform has a lot of independent operation links, and one of them named "Team Building" is chosen as an assessment example.

Team building, refers to the process that CEOs simulate personnel recruitment of their enterprises, including creating department and position (authority distribution included) as E1, releasing recruitment notice (according to position) as E2, receiving resumes as E3, screening resumes as E4, providing offers as E5, receiving applicant feedback as E6, completing recruitment as E7. The major transferable skills tested in this link are planning capability ("can the CEO organize his/her enterprise and make plan well?") and interpersonal influence ("can the CEO attract other to join his/her enterprise, and is the CEO popular in class?"). Make Ek0 the start event of team building, thus the most perfect critical path is shown as (1), which means CEO smoothly completes team in the shortest way.

$$E_{k0} \rightarrow E_{k1} \rightarrow E_{k2} \rightarrow E_{k4} \rightarrow E_{k5} \rightarrow E_{k6} \rightarrow E_{k7} \quad (1)$$

But in fact, in most cases, it is difficult for a CEO to finish the task in such ideal way like (1). Situations may occur during the team building: after releasing the recruitment notice, CEO realizes that the position setting is unreasonable so that he/she has to adjust the positions and accordingly release the recruitment notice again, as in (2); when one round recruitment is finished, there are some positions still vacant so CEO need to repeat the recruitment again.

$$E_{k0} \rightarrow E_{k1} \rightarrow E_{k2} \rightarrow E_{k1}' \rightarrow E_{k2}' \rightarrow E_{k4} \rightarrow E_{k5} \rightarrow E_{k6} \rightarrow E_{k7} \quad (2)$$

Under the circumstances, to ensure that a critical node in the linked list is latest, it is necessary to search the last critical node of the same event and update it to a non-critical node, when a new critical node is inserted into the list. At this point, Equation (2) should be changed to Equation (3).

$$E_{k0} \rightarrow E_{1} \rightarrow E_{1} \rightarrow E_{k1} \rightarrow E_{k2} \rightarrow E_{k4} \rightarrow E_{k5} \rightarrow E_{k6} \rightarrow E_{k7} \quad (3)$$

Using fuzzy matching strategy to match the operation information list of CEO with the critical path, as in (1), could determine whether the CEO had completed the entire team building process, then judged the complexity of the non-critical sub-paths, including time spent and repeat times. If CEO had finished this link, the "length" of his/her operation list was shorter, the better score he/she would get in planning capability and interpersonal influence. Conversely, if the complexity of non-critical paths was high, that meant the CEO was under performance of these two abilities. In addition, result data was also used as assessment standard, such as the quantity of resumes received by CEO, the number of positions recruited successfully in the same round recruitment, and regular data like clicks and glance time of the notice, etc.

The assessment of CEOs' planning capability and interpersonal influence reflected in team building was achieved using the AA method. But it was just part of the overall assessment of these two abilities, with summary of weighted assessment of each link, we could acquire relatively objective and comprehensive assessment data.

4 CONCLUSIONS & FUTURE WORK

This paper integrates the advantages of the AA methods based on operation result and operation sequence, and put forward a new AA method for the transferable skills.

The method proposes a standardized way for user behavior in simulation environment, and has greatly improved the efficiency in collecting valid user operation information. The method uses both operation result and operation sequence as assessment criteria so that it can achieve more comprehensive and objective assessment results.

Moreover, this AA method has good versatility, and is flexible to make appropriate adjustments according to requirements of the automatic assessment environment. This paper describes an instantiated application of the method in a simulation platform, and realizes simple automatic assessment of transaction skills. Although the method may not be mature enough, it provides methodology foundation for the automatic assessment technology of transferable skills.

In future work, this method could be further improved in the following ways: the perfection of rule base mentioned in Section 2.3 is artificial, so we will introduce machine learning strategy into the method to achieve the automatic improvement of the rule base; we will also make further application of the method to more assessment environment, and collect application feedback and result data to improve this AA framework and method.

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Towards a Support System for Course Design

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Abstract: Many stakeholders in higher education develop with time. In this paper, we propose a new type of platform, called a Teaching Content Management System (TCMS). Such platforms are intended for instructors to help them produce teaching specifications and quality teaching designs. We first of all present drivers of change that currently affect universities and we discuss some specific aspects of education in higher education. We then derive a set of support requirements for instructors and provide a services design that TCMS should comply with.

1 INTRODUCTION

Learning Content Management Systems (LCMS), also called Learning Management Systems (LMS) have been developed gradually over the past fifteen years across all levels of education (Zou et al., 2012). These Internet-based platforms are mainly designed to foster the creation and sharing of content, and interaction between instructors and students, by using the Web (Bennett et al., 2006). Almost all universities make LCMS available to their students and instructors such platforms as Blackboard (http://www.blackboard.com) or Moodle (http://moodle.org). LCMS platforms provide rich opportunities for teaching students, but few opportunities, if any, to help instructors in specifying and designing their teaching courses.

Therefore, most instructors manage the preparation and design of their courses in a traditional manner and are poorly equipped in information technology in the area of specification and design of their teaching courses (Ottenbreit-Leftwich et al., 2012). The question of developing a support system to help instructors to specify and professionally manage the construction of their teaching courses was raised with a view to supplement LCMS. In Section 2, we first show the development factors and constraints that currently weigh on higher education. In Section 3, we set out the objectives for TCMS in the form of strategic support requirements that the TCMS should satisfy, based on the analysis of the previous section, some specific aspects of higher education and our long years of experience in higher education. In Section 4, we then propose a preliminary design in the form of a system comprising three support axes that are detailed as follows: 1) improving instructor knowledge and professional skills 2) management of a professional knowledge base 3) project realization. In Section 5 we discuss about TCMS as a new concept and also about its practical implementation and usefulness. In Section 6, we offer our conclusions and perspectives for future research.

2 STATE OF ART OF DEVELOPMENT FACTORS WEIGHING ON HIGHER EDUCATION

The profession of instructor has been changed by several development factors in recent years. Six important factors are presented in this section.

An initial factor relates to the continuing progress of ICT that transcends communication, coordination, knowledge management, production of learning tool or objects and the scripting of teaching.

This first factor has caused the President of Stanford University to state *"Just as technology disrupted and transformed the newspaper and music industries, it is now poised to wreak havoc upon another established industry: higher education"* (Hennessy, 2012).

A second factor relates to how the mission entrusted to higher education has developed. Thus, a vast professionalization movement has lead to the requirement of providing training programs that are closer to the concerns of businesses while seeking to provide training throughout life (Pisa, 2005). This leads to an evolution in the perception of knowledge and to the development of curricula definitions based on skills and business rationale with more useful knowledge that can be immediately applied (D'Andrea and Gosling, 2005).

A third factor relates to the professionalization of instructors and educational systems. It is reflected in the many reforms of university systems and a vast movement for the development of quality assurance (Manjula and Vaideeswaran, 2011). It participates in the consideration of teaching as a project where the product is student learning (Van Rooij, 2010).

A fourth factor relates to the changing profile of students, particularly in respect of their number and behaviour. This "Y" generation is more critical of the relevance of knowledge that the university wishes to teach it, than the previous generation (Roberson, 2011). Thus, we need a teaching design framework that produces more elaborate teaching activities capable of adapting to this new audience.

A fifth factor is the considerable growth and diversification of knowledge taught. This makes knowledge more difficult to acquire and less sustainable. Thus the search of knowledge and it capitalization are becoming fondamental.

A sixth factor relates to advances in the diffusion of research in teaching and learning. Indeed during the last two decades, this research has led to the emergence of new ideas such as active learning, significant learning, and educative assessment. These techniques are better suited to new student profiles and enable the development of learning techniques that are closer to current training needs (Warin et al., 2011a).

This state of art shows that the knowledge and skills that are now required for an instructor are no longer confined exclusively to their subject, but also relate to the use of Information Technology and Communication (ICT), teaching systems, student profile and expectations, the development of knowledge and teaching methods. The major challenge for instructors is no longer access to knowledge but the ability to take ownership of it, to organize relevant educational activities to enhance the learning of their students, and to justify themselves economically within the educational system.

3 PROPOSITION: TCMS AS NEW TYPE OF SUPPORT SYSTEM

Thus, the question of developing a support system to help instructors to specify and professionally manage the construction of their teaching courses was raised. The top diagram in Figure 1 shows that TCMS will help instructors by impacting on their teaching knowledge, subject knowledge, etc., as well as on their work methods and organization. Its goal will be to foster the creation or development of teaching, improve instructor skills and integrate developments that weigh on higher education. The entire Figure 1 shows the differences in requirements, constraints and objectives between TCMS and LCMS. The purpose of TCMS is teaching specification and design, whereas the purpose of LCMS is the implementation and monitoring of teaching with students.

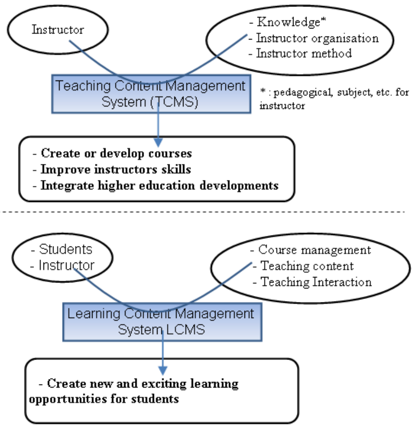


Figure 1: TCMS versus LCMS.

From an operational strategy perspective, current technology makes it possible to foresee an Internet based client / server tool, accessible anywhere, anytime, on various media from a PC to a smartphone. In fact, TCMS could use current technology platforms such as Moodle and even be directly integrated into them.

From a strategy point of view of functional requirements: the support to be provided must take into account the specific manner that Higher

Education instructors operate, who, for the most have never learned to teach (Bergin et al., 2001), must devote an important part of their activities to research, upon which their recognition and promotion are based (Harzing, 2010), and finally, for which the systematic creation principles or methods of current learning systems, such as the highly structured ADDIE (Molenda, 2003) or MISA (Paquette, 2010), do not correspond to their work traditions. Having to learn to use any computer-software teaching tool is one of the major hindrances to their use (Rößling et al., 2008). Thus, TCMS should incorporate its own learning system and be used at different levels of expertise adapted to the skills of the instructor who uses it.

4 THREEFOLD DESIGN OF TCMS

In order to assist instructor in these new challenges, we suggest that TCMS be built around three support axes: 1) Improving the instructor knowledge and professions skills 2) Management of a professional knowledge base and 3) Project realization. These three axes are detailed here after. This threefold design enables ownership to be taken in an iterative and incremental manner. The instructor is free to use one or more axes. Inside the first axis, ownership can be taken through several levels provided by a framework based on five sub-axes. Thus the instructor is free to build their engineering at their own pace. In doing so, our platform can include both the first time instructor, or the inexperienced instructor, and the experienced instructor.

4.1 Support for Improving Instructor Knowledge and Professional Skills

Providing support to instructors by making updated knowledge and skills related to their instructor profession available to them. This axis will not simply be a mere repository of knowledge, but will also offer activities to learn and master these skills and knowledge. We propose that this axis be structured and developed through a framework that consists of five quality sub-axes: (1) Teaching technique, (2) Subjects (knowledge to be taught), (3) Scripting (4) Technology and (5) Research and innovation. Using a framework to frame the content of this axis has two advantages: it will organize the implementation of the future system, but it will also, by being designed with relatively independent sub-axes, offer multiple entries to future teaching users that will facilitate the full adhesion of instructors to the system, through the possibility of gradual ownership.

Teaching Technique. This sub-axis relates to teaching basics. Its goal is to help instructors in identifying and taking ownership of basic teaching techniques. This sub-axis of the future platform will be responsible for managing teaching basics and basic teaching techniques, such as: knowing how to classify knowledge to be taught, knowing how to define educational objectives, knowing student learning conditions and strategies, etc. This part will be based on the classical works of Bloom, Krathwohl, Mager, Glaser, Gagne, Jonassen, etc., for which we do not provide an exhaustive list of references in this article due to lack of space. An interested reader can refer to Talon et al. (2012) for more information. The knowledge required for the "Teaching Technique" sub-axis is more of the academic knowledge type and will require limited effort by the instructor to master.

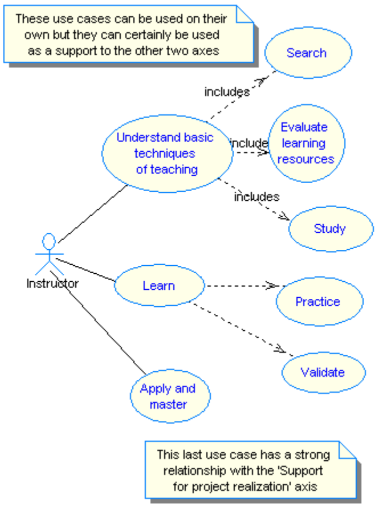


Figure 2: High-level use case of the “Support for improving instructor knowledge and professional skills” axis.

This "Teaching technique" sub-axis will also offer, 1) learning activities to learn the basic teaching techniques, 2) software for validating teaching knowledge, and 3) course definition tools. All or part of the results produced, such as the teaching objectives, can be automatically exported, depending on the opportunity, to the LCMS part of the platform to be brought to the knowledge of students. Figure 2 illustrates the main use cases for this "Teaching Technique" sub-axis. These use cases are written in the well-known UML language (http://www.uml.org/).

Subjects. This sub-axis relates to the content to be taught: computer science, mathematics, languages, etc. It aims to make resources validated by the best experts in the field available to instructors. Semi-automatic quality assessment tools of *a priori* resources can be integrated into this sub-axis. Indeed, an unidentified or authorless resource can be detected a priori as being of lesser quality. Similarly, in order to be classified as quality, these resources should not be mere knowledge repositories, but must be "comprehensive" in the sense that they must be accompanied by a teaching framework that facilitates their ownership or adaptation by the instructor: context, wording, specific correction elements, precise evaluation criteria, feedback, etc. Professional monitoring, based on peer review and feedback, can be put in place to assess the quality and relevance of resources.

Scripting. This sub-axis relates to more developed and more practical knowledge in relation to teaching. It aims to enable instructors to identify and take ownership of complex teaching strategies, such as, for example, serious games techniques or project-based learning. The volume and complexity of additional knowledge that instructors have to master is not the same as those of the "Teaching.

Technology. This sub-axis relates to the technology for helping instructors in relation to teaching methods. These are generic tools, whereas the technology tools related to the subject taught will be associated with the "Subjects" sub-axis. For example, visualization software to run a sorting algorithm will be integrated into the “Subjects” sub-axis. The purpose of this "Technology" sub-axis is to facilitate the use of ICT by instructors to manage their teaching activities. For example, in the near future, instructors that have mastered the Moodle or Blackboard type e-learning platform will have a distinct advantage. All the more as there are recent techniques that facilitate their configuration (Drira et al., 2011).

Research and Innovation. This sub-axis relates to knowledge, processes and tools that facilitate the production of knowledge and innovation practices. It aims to help instructors in mastering the techniques of knowledge acquisition or creation, be they teaching or subject knowledge as advocated by Labour and Kolski (2010). It is important that an instructor masters access to bibliography databases and to simple techniques, that are not well know by many instructors, in relation to quality indices such the impact factor, the h-index and the g-index (Harzing, 2010), etc.

4.2 Support for the Management of a Professional Knowledge

Whether to support the creation or development of their teaching or to achieve research results, instructors need to improve and manage their professional knowledge. The purpose of this axis is to provide a content management system that enables them to store, classify and enrich their professional knowledge.

In this content management system we need to distinguish free knowledge from other knowledge. Free knowledge can be freely modified and distributed without charge by the instructor. Free knowledge, even if there are different modalities of implementation (http://creativecommons.org) is the only knowledge that the teacher can reuse, improve, adapt and distribute for free during his teachings. The concept of free knowledge is important because it allows the teacher to remain master of his own issues: reducing the time spent in preparation, high quality educational resources provided, accuracy of knowledge disseminated and adaptation to the student audience.

Traditional knowledge can be managed effectively in the TCMS with bibliographic management tools such as for example, Mendeley software (http://Mendeley.com), possibly with additional functions and search rankings. Free knowledge included in the TCMS will be managed using a tool that combines the functions of a traditional CMS for its ability to store and organize knowledge, with those of a versioning tool. Evolutions must be stored including dates and major changes but also the identification of their contributors. Free knowledge does not mean anonymous knowledge. In addition, in connection with the third axis, *Support for project realization*, the tool will provide support for the capitalization of knowledge, acquired during the implementation of these third axis projects.

4.3 Support for Project Realization

This is the provision of support for the good management of instructor activities during the preparation and implementation of their teaching courses. We recommend a project management approach, in the sense of industrial project management (PMBOK, 2008). In this context, the TCMS will encourage and support the instructor, via the available tools, to rigorously set their teaching specification: topics, prerequisites, content, teaching objectives, start and end dates, specific material conditions, etc. It will also enable the incorporation of specific context: implementation of teaching objectives, estimated time set aside for preparation, the instructor's level of command of the subject being taught, the instructor's personal goals in respect of the teaching, etc.

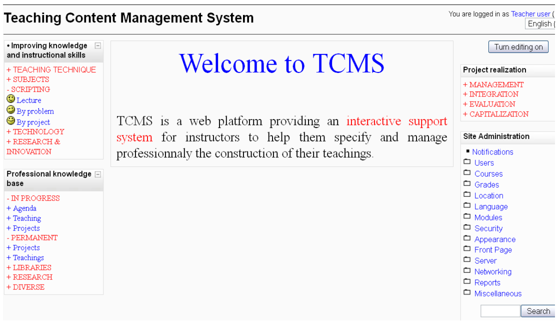
A major objective of the specification of this project mode is to get the instructors to capitalize the fruit of their teaching over course to be taken from one year to another and to be enriched, etc., but it should also support instructors in bringing together several teaching courses, whether they come from them or from a colleague.

5 DISCUSSION

In this section we discuss if TCMS is a new concept and also we discuss its practical implementation and usefulness.

Related Works. The first question concerns existing previous works. Is this concept of TCMS new? Are there existing tools to support it? In our literature search we found similarities with the proposed concept in the Drona work of Anjali (2011). However, no theoretical support is given. There is also little detail. Some other works such as (Polson et al., 2005) introduce a TCMS but reading the relevant articles shows that they actually speak of an LCMS not of a TCMS. Several works such as (Juang et al., 2008), which are interested in improving teaching skills and teaching practices, are more interested by the relationship between teacher and his institution. Again these works cover a very small part of axis 3 of the TCMS. They do not offer a global solution to the teacher. We could not cite all the research related to our proposal, particularly the works carried out by the English-speaking institutions (English, American, Australian and Canadian) in the movement "scholarship of teaching and learning" (SoTL, http). However, to the best of our knowledge, the concept of TCMS proposed in this article is new, or at least very little developed so far in the literature.

Design Choice. The second question in this discussion is the design of our tool. What type (s) of tool (s) to develop? Apart from the fact that it will be Web-based, several options are available to us. We chose to develop it by integrating it in a CMS. For our first tests, we chose the popular Moodle platform. Figure 3 shows a possible integration that takes advantage of the malleability of Moodle in which three spaces were created for the three axes described in this article. This type of development that will reuse part of the back-office, such as user management, should also promote the adoption of our tool by teachers who are already using this type of LCMS (of course, assessment will carried out to prove this) and facilitate the provision to students of lessons designed by teachers.



TCMS is a web platform providing an interactive support system for instructors to help them specify and manage professionnaly the construction of their teachings.

Figure 3: Mock-up of the TCMS home page.

Utility Considerations. The third question concerns the usefulness of such a platform. Would these tools be useful? Our specifications were used in few courses. Some of the tools used were MS-Project and the Moodle platform. A part of implementation has however been done manually. As result of this first experimentation, teachers concerned won an Award for Educational Innovation in a contest that involved seven French universities (Warin et al., 2011b). These teachers did not follow all the suggestions of our specification, but those that were contributed to the winning.

6 CONCLUSIONS

This article looked at instructor-centered teaching engineering in academia. We highlighted six major development factors that require the rethinking of instructor work methods. We proposed a supplement to LCMS introduced in universities by adding a new type of feature: Teaching Content Management System (TCMS). The goal of a TCMS is to support instructors in the specification and design of their teaching so that they reach a high level of professionalism. We have emphasized that TCMS should be designed to enable iterative and incremental ownership. We therefore proposed a general design of the services that TCMS should offer. The first prototype of a TCMS is under development. It aims to make the system more holistic than the short presentation in three axes suggests. Next works will focus to prove that its use provides assistance to engage the instructor in reflexive inquiry of its practices and facilitates opportunities to work with other colleagues. Indeed, a collective effort should be based on individual strong skills: to be a strong individual support to the instructor it's exactly the purpose of a TCMS.

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Monitoring and Evaluation Problems in Higer Education
Comprehensive Assessment Framework Development

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Keywords: Monitoring and Evaluation, Information System, Comprehensive Assessment, Education Quality, Partial Credit Model.

Abstract: The work is devoted to evaluation component introduction into higher education management systems. Three classes of problems of comprehensive assessment are considered. The appropriate assessment models are suggested. The case study is related to comprehensive assessment of education quality based on the level of students' satisfaction.

1 INTRODUCTION

Information technologies (IT) are the powerful tool of increasing the efficiency of decision-making processes. The formalization of management problems and usage of appropriate mathematical models provide IT with tools for solving application problems. This allows to increase business performance in different domains. Higher education is a unique social and economical area. The quality of its functioning influences many processes of development of society. Therefore the elaboration of IT in higher education domain remains the important problem for specialists of different sciences.

The existing information systems (IS) of different higher education establishments (HEEs) can be classified by functionality, relation to educational process, producer and implementation technology (Krukov and Shahgeldyan, 2007).

IS functionality corresponds to definite kind of HEE's activities. IS of HEEs may be related to educational process or may automate some financial and administrative functions which are similar for different organizations and enterprises. IS can be elaborated by HEE itself to satisfy its needs. The commercial software is an alternative, it is created by IT-companies and is distributed on the software market. IS for HEE management can be realized based on a single or several technologies. Analyzing existing software for HEE management we can make a conclusion that the process of decision-making is still not enough automated.

Independently of the domain, the process of decision-making has the following stages: goal formulation, forming the set of possible alternatives, evaluation, and selection of the best alternative (Meyer and Booker, 2001). Monitoring and evaluation (M&E) subsystem provides measurement tools for estimation of different activities, projects and outcomes.

Automation of M&E is an urgent problem that has found many industrial solutions in different areas of public life. For example, environment monitoring IS provide data about ecological situation of some region, country or the earth that reflects the state of air, water, lands, threatened species, etc. (Athanasiadis and Mitkas, 2004). Education monitoring IS collect and process information on the level of HEE or some management agencies (Carrizo, et.al., 2003). Healthcare also needs IS of M&E (Health Monitoring, 2012).

M&E includes many subproblems (for example, indicators construction, data collection, comprehensive assessment). In this work we consider different classes of problems of comprehensive assessment (CA). Our aim is to improve decision-making process by means of useful CA components elaboration. CA software must be developed taking into account the following requirements of evaluation models: evidentiary and unification character, quantitative estimates, transparency and reliability.

The rest of the paper is organized in the following way. Section 2 describes the directions of researches devoted to education quality assessment. Section 3 represents three classes of problems of CA. The case study of the students' satisfaction evaluation is given in section 4. The conclusions and future work are presented in section 5.

2 ISSUES OF EDUCATION QUALITY ASSESSMENT

The necessity of quality assessment in higher education is not in doubt. The solution of this problem depends on two basic aspects: the understanding of the concept of education quality and methods of its evaluation.

The concept of education quality is interpreted in different ways. The most common way is to consider education quality as collection of knowledge and skills obtained during the educational process (Koenig, 2011). In addition from functional point of view education quality can be considered as service characteristic, process attribute or HEE resources feature (EFQM, 2003). Spacial aspect enforces analysis of education quality on different management levels: university, region, country (Kachalov, 2001). Time aspect leads to considering of education quality as feature suggested by HEE or expected and perceived by consumers (Oliveira and Ferreira, 2009).

Variety of ways of education quality concept definition leads to elaboration of different methods of its assessment. There are many works in this direction, and the results may be divided into two subcategories: methods of experts' judgments and methods of psychometric theory. Experts methods are developing independently of application domain in decision-making theory (Brown 2005). The main disadvantage of these methods is experts' subjectivity. On the other hand, test theories apply statistical analysis for substantiation of knowledge testing results (Wright and Stone, 1999).

So education quality is a complex, multi-aspect, heterogeneous object. Its assessment must take into account the multidimensionality and heterogeneity of the object itself, dispersion of possible values and different measurement scales. Since the quality category covers different aspects, this work considers the peculiarities of the comprehensive quality assessment. Many problems in this domain remain unsolved. In most cases the comprehensive estimate is found as arithmetical mean not taking into account the heterogeneous structure of the complex object. All these issues make the CA problem interesting for our research.

3 CLASSIFICATION OF COMPREHENSIVE ASSESSMENT PROBLEMS

To assess quality of any object it is necessary to define the set of indicators, which reflect the state of an object, and the model which determine its quantitative measure.

We discovered that the problem of construction of set of indicators has some solutions. They include the approaches based on Qualimetry Theory (Azgaldov, 1982), which substantiate the rules of construction of indicators system, and Rasch theory (Wright and Stone, 1999), which considers the probabilistic models of estimation of latent variables for the substantiated set of observed indicators.

The model of quality assessment is determined by management goals. HEE management may be interested in solving the following problems: assessing the potential of existing facilities in HEE, assessing the actual quality of provided services and finally assessing performance of educational system. In most cases the solution of mentioned problems require comprehensive assessment of education quality.

There are different issues of CA which can be formalized in different ways depending on the object of assessment. From the point of view of goals and tasks of management we can distinguish three classes of CA problems.

The first class is represented by CA of stakeholders' requirements satisfaction. These requirements are described in normative conditions and specifications. The examples of tasks of this class are the assessment of HEE readiness to licensing or accreditation; the estimation of candidate while employment (e.g., on professor post).

The second class includes CA problems of quality as a characteristic that bears ability to satisfy potential needs. The problems of this class include: construction of HEEs rating, the estimation of learning results (examinations, testing), assessment of resources quality.

The third class of problems consists in CA of performance, which reflects the results of a considered object usage. The tasks of CA of performance may include the following: evaluation of outcomes of HEE activities, estimation of the profit of resources development, evaluation of HEE's management projects and programs realization.

In the first class of problems the CA value is strictly determined by requirements. The main goal of such assessment is to define whether the object satisfies all requirements from specification. The degree of how well the requirements are fulfilled is not considered. Evaluation process in this case can be modeled based on switch chains. We take the notion of switch chains from the Theory of Intelligence (Bondarenko and Shabanov-Kushnarenko, 2006). A switch chain consists of a set of basic Boolean functions (conjunction, disjunction and negation, etc.). The combinations of those functions allow modeling of different complex objects.

The main problem of CA of the second class is the way of aggregation of estimates by different criteria. In this class of problems the quality is expressed as a totality of object's features. Therefore in general each feature is evaluated separately and then the CA is done. From our point of view the most advanced approach to solve this problem is represented by Qualimetry Theory (Azgaldov, 1982). It provides theoretical basis of quality assessment. According to qualimetry the quality is represented as hierarchy of properties of assessment object. Based on the set of certain axioms the property tree of object's quality is constructed. The top point of the property tree is object's quality; it consists of a set of simple and composite properties and has a hierarchical structure. Qualimetry suggests estimation of all simple properties and calculation the CA value with the help of one of weighted mean methods.

In the case when we deal with heterogeneous object (for example, educational process resources, customer outcomes in HEE) the construction of property tree appears to be an unsolvable problem. As a rule, such objects can be represented as a set of separate elements which involve own quality features. Due to expert judgments used for the property tree construction it is impossible to represent a heterogeneous object by means of a set of simple properties. It leads to the idea of partitioning of evaluation process in two main stages. The first one is evaluation of separate elements, as a result partial estimates are defined. For this purpose qualimetry approach is applicable. The second stage is aggregation of obtained partial estimates into the CA.

We suggest to use a network model for CA of quality of heterogeneous object (Cherednichenko et. al., 2012). The CA is done using composite functions (for example, arithmetical or geometrical weighted means). Evaluation framework is represented as a graph with two types of nodes. Nodes-entries of this graph are associated with partial estimates. Nodes-aggregates express the estimate of group of elements based on particular composite function.

The third class of CA problems implies the estimation from the point of view of customer value. In this case the assessment object can be represented through latent variables that influence the observable attributes. Based on heuristic procedure the set of indicators is constructed. We think that values of these indicators have to be obtained with the help of statistical data collection. This causes application of statistical analysis for the CA value calculation.

The CA is done using probability-based reasoning. It is assumed that unknown value of latent variable is expressed through the function of probability of obtaining some definite value of each indicator. The probabilistic function is determined by statistical model. For example, to estimate learning results Rasch model can be used. It allows defining person's ability based on answers to questions of the test (Wright and Stone, 1999).

Therefore three classes of problems have different assessment focuses, ways of inputs definition and aggregation models (Table 1). The class of the problem defines assessment focus and aggregation model, but inputs may vary for each application case.

Table 1: Comprehensive assessment classes of problems.

Class	Assessment focus	Inputs	Aggregation model
I	Fulfillment of all stated requirements	Expert judgment	Switch chain based on Boolean functions
II	Possibilities of totality of quality features	Partial estimates of separate elements	Comprehensive assessment network
III	Performance of customers outcomes	Collected statistical data	Probability-based reasoning

4 CASE STUDY

Our case study represents the CA of students' satisfaction of education quality. Since we have already made researches in evaluation of students' satisfaction, we have chosen this case study to demonstrate applications of CA models considered above (Cherednichenko and Yangolenko, 2012).

We suggest to evaluate education quality as the quality of services based on SERVQUAL method (Parasurman et. al., 1985). According to it the service quality is considered in terms of five SERVQUAL dimensions: tangibility, reliability, responsibility, security and empathy. The SERVQUAL is targeted on revelation of expected and perceived service quality. We consider the adaptation of original SERVQUAL questionnaire for measuring education service quality (Oliveira and Ferreira, 2009). We suggest to use the single questionnaire with 19 questions that define the gap between the perceived and expected education quality as it is described in our previous work (Cherednichenko and Yangolenko, 2012). The questions are scored using 7-points scale. The scores range from 1, which means a strong negative difference between perceived and expected quality (so the expectations were not justified), through 4, which denotes the absence of any gap, to 7, which means a strong positive difference (the perceived reality turned out to be much better than expectations).

We have conducted a survey of 75 four-year students of our department. To process the students' answers we chose the following Item Response Theory models: Rasch model (RM) and Partial Credit model (PCM) (Reeve, 2011).

Since RM provides processing of dichotomous questionnaire data, students' answers have to be converted into dichotomous scale related to positive or negative gap. The probability $P(x_{ij})$ of i-th student to answer positively on j-th question is described by the following dependency:

$$P(x_{ij} = 1 \mid \theta_i, \beta_j) = \frac{\exp(\theta_i - \beta_j)}{1 + \exp(\theta_i - \beta_j)}, \qquad (1)$$

where θ_i is a satisfaction level of i-th student; β_j is difficulty of j-th question.

According to PCM the probability of the event that i-th student gives x points for j-th question is expressed as:

$$P(u_i = x \mid \theta_i) = \frac{\sum_{k=0}^{x} (\theta_i - \delta_{jk})}{\sum_{h=0}^{m_j} \exp \sum_{k=0}^{h} (\theta_i - \delta_{jk})}, \qquad (2)$$
$$x = 0, 1, ..., m_j,$$

where θ_i is satisfaction level of i-th student; δ_{jk} is the difficulty of j-th question which defines the probability of selection of value x instead of x-1.

The overall estimation of perceived quality based on the answers on 19 questions according to both measurement models is given in Table 2. We find the descriptive statistics of obtained results (minimal and maximal values, mode, median, mean standard error – MSE and standard deviation – SD). The obtained values of students' satisfaction θ_i are measured in logits and are the input data for the CA.

Table 2: Overall students satisfaction estimate.

Model	Mean	Min	Max	Mode	Median	MSE	SD
Rasch	1,9	-2,44	4,44	4,44	1,51	0,94	1,86
PCM	0,1	-1,76	1,64	-0,25	-0,06	0,2	0,68

In the case when we evaluate education quality we need to make CA of students' satisfaction that can be defined through aggregation of θ_i parameters. The estimate of the quality criterion is calculated as mean of corresponding students' satisfaction estimates. Mean estimates are taken as intermediate aggregate estimates. CA value is calculated by aggregation of those intermediate estimates.

Quality criteria values and descriptive statistics of obtained estimates are given in Table 3 and Table 4. Each dimension is considered as education quality criterion (1 – tangibility, 2 – reliability, 3 – responsibility, 4 – security, 5 – empathy).

Table 3: Analysis of students satisfaction estimates according to RM.

Quality criterion	Mean	Min	Max	Mode	Median	MSE	SD
1	1,9	-4,4	3,77	3,77	2,04	1,7	2,12
2	1,23	-2,6	2,75	2,75	2,75	1,8	1,89
3	1,45	-2,52	2,53	2,53	2,53	1,52	1,33
4	1,65	-2,52	2,51	2,51	2,51	1,56	1,17
5	1,00	-2,54	2,56	2,56	1,15	1,48	1,61

We can see that PCM provides estimates of students' satisfaction in more differentiate manner. This is due to the bigger number of grades of answers to each question than in RM.

Table 4: Analysis of students satisfaction estimates according to PCM.

Quality criterion	Mean	Min	Max	Mode	Median	MSE	SD
1	0,16	-2,35	4,26	0,54	-0,04	0,52	1,18
2	-0,04	-5,57	3,5	-0,23	-0,23	0,68	0,68
3	0,28	-2,54	5,39	0,42	0,21	0,53	1,17
4	0,32	-1,48	2,74	0,09	0,09	0,52	0,99
5	0,03	-3,6	2,84	-0,26	-0,05	0,53	1,23

errors for RM are greater than for PCM which indicates a smaller dispersion of estimates for PCM. So estimates obtained with the help of PCM are more adequate and preferable.

Since PCM is more adequate we calculate weighted and unweighted arithmetical means (WAM and UWAM) and geometrical means (WGM and UWGM) only for this model. To find WAM and WGM the following weight coefficients were used: α1 = 0,27, α2 = 0,2, α3 = 0,15, α4 = 0,25, α5 = 0,13. The obtained results are the following: UWAM = 0,15, WAM = 0,16, UWGM = -0,11, WGM = -0,13.

So these results are close to overall satisfaction level equal to 0,1 which was found as the mean of θ_i (Table 2). Using such decomposition except aggregated estimate we can find intermediate estimates. Furthermore we can assign different weight coefficient to make the comprehensive result more suitable for the purposes of decision-making.

In the case when we evaluate whether the quality perceived by students corresponds to the given level, we deal with the CA problem of the first class. Such estimate can be found based on input data which are the estimates of students' satisfaction by five quality criteria. The switch chain consists of three layers of Boolean functions. The first layer is represented by the function that defines whether each student's satisfaction value is greater than defined level (it returns 1, if this requirement is fulfilled, 0 – otherwise). We take the median $\theta = -0{,}06$. The function of the second layer checks whether a single criterion is assessed positively, i.e. the most of satisfaction values of single criterion are greater than defined level. In our case the estimates given by more than 37 students have to be bigger than the defined level. The third layer function defines whether the requirement to satisfaction level over all criteria is fulfilled. In this case study at least 3 criteria must meet the requirement. Under the value $\theta = -0{,}6$ we found out that the perceived quality is satisfactory.

To accomplish our case study we made the CA of the third class. As CA we take the estimate of proposed quality. The main hypothesis is that proposed quality defines the estimates of perceived quality. We suppose that these estimates correspond to calculated θ_i. To find CA value we suggest to use Spearman Single Factor Model. We obtained value of proposed quality equal to 1,97 logits. This corresponds to enough level of educational services.

The obtained results showed the satisfactory education quality from three different points of view. Therefore we suggest to use described approach for implementation of M&E IS.

5 CONCLUSIONS AND FUTURE WORK

According to the functionality classification the following IS can be distinguished: systems of administrative, financial and economic management; systems of educational process management and support; systems of scientific and research work management; systems of information resources management.

All of them should contain the CA unit. Due to goals and management tasks the different models can be used. We have realized three main classes of CA problems. The certain framework is associated with every problem's class.

We have discovered the most advanced procedures of CA. They are expert judgments, qualimetric practices or statistical analysis for initial estimates (inputs of CA). We suggest Switch Chains, Network Assessment and Probability-based Reasoning in order to construct comprehensive assessment model. Our researches are strictly devoted to implementation of CA procedures. On the other hand, we have tried to generalize our experience to provide some formal approach.

The investigation of the case-study shows potential possibilities of suggested frameworks usage. We should note that the estimation of students' satisfaction is not the clearest way to demonstrate the advantages of our approach. But we hope that the aim of illustration how different tasks influence comprehensive assessment is reached.

As a result of this work we can underline the following: 1) the process of CA is represented in two stages: estimation of separate elements and their aggregation into CA value; 2) three classes of problems and CA frameworks related to those classes are defined; 3) the set of experiments based on evaluation of students' satisfaction were done; 4) the principle role of probability-based reasoning methods for performance evaluation is proved.

Therefore, the suggested CA frameworks can be used for M&E Software elaboration. The future researches will be connected with the up-to-date CA tasks in HEE. Our researches are aimed at development of M&E models and IT that can be applicable in higher education as well as in other domains.

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Breaking the Flow

Examining the Link between Flow and Learning in Computer-Mediated Learning Environments

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Abstract: In the context of research concerning computer-mediated learning environments (CMLEs), the construct of flow, or optimal experience, has been positively linked with students' learning outcomes, such as affective and cognitive perceptions of learning and the development of academic skills. However, this linkage is compromised by inconsistent characterizations of flow across studies and divergent measures of when flow may have occurred during learning. Further, characterizations of learning have differed across studies (i.e. self-reported attitudes about one's learning experience or one's academic achievement). In this paper, we review these inconsistencies and discuss how meta-analysis may be one means by which we can examine whether flow does impact learning within CMLEs, given the differing operationalizations of flow and learning that are found within the extant literature.

1 INTRODUCTION

The concept of flow, or optimal experience, as first introduced by Mihalyi Csikszentmihalyi (Csikszentmihalyi, 1990), has been examined in the context of diverse activities such as sports, classroom learning, and more recently online and computer-mediated learning environments (de Freitas and Neumann, 2009; Liao, 2006; Shin, 2006; Voiskounsky, 2008). Flow can be characterized as a state in which individuals are “in the zone” or immersed in the task at hand, such that concerns about performance become less salient. Further, Csikszentmihalyi (1990) has likened flow to optimal performance, positive feelings of well-being, and enjoyment. In the academic realm, flow has been associated with enhanced academic performance, particularly in traditional classroom settings. For example, high school students who reported experiencing flow while writing English essays submitted better work and were more engaged in the activity than students who did not report as such (Larson, 1988). In the online learning realm, Liao (2006) found that college students who reported being in flow during their online courses were more likely to engage in online course activities than those who were not in flow.

The linkage between factors such as flow and learning has garnered much research attention particularly in computer-mediated learning contexts (Konradt, Filip, and Hoffman, 2003; Liao, 2006; Shin, 2006), which includes learning via mobile device applications and online learning modules. These contexts are becoming increasingly ubiquitous in higher education (Allen and Seaman, 2010). Online learning in this context refers to courses whereby all or a significant portion of the instruction and learning activities are presented via the Internet. Findings show that learning outcomes in online courses are comparable to, or in some cases, superior to learning in traditional classroom environments (Allen, Mabry, Mattrey, Bourhis, Titsworth and Burrell, 2004). One contributing factor to enhanced academic performance in online learning environments is the engagement they evoke (Arbaugh, 2010). In fact, some researchers contend that online learning environments or computer-mediated environments (CMEs) in general promote flow (Chen, Wigand, and Nilan, 1998; Hoffman and Novak, 1996; Liao, 2006). One striking issue that has plagued this work, however, is the diversity of operationalizations and measurements of flow. This situation compromises conclusions that can be drawn about how flow may impact learning in these environments.

Initial characterizations of flow in CMEs were drawn from Hoffman and Novak (1996) whose characterization of the components of flow as experienced during web browsing were adapted by other researchers. Hoffman and Novak's model of flow replicated much of Csikszentmihalyi's original formulation (as discussed below) and constructs derived from the media literature including interactivity and telepresence. Researchers (Chen, et al., 1998; Choi, Kim and Kim, 2007; Novak, Hoffman and Yung 2000) then modified Hoffman and Novak's (1996) framework to investigate flow in CMEs often with far less extensive characterizations of flow that fell far short of Csikszentmihalyi's original formulation (Liu, et al., 2011). Thus, diverse characterizations of flow have been reflected in the CME literature, which includes similarly diverse means of measuring flow. For example, researchers have assessed flow experiences via surveys that span diverse time frames in which individuals may attain and lose the flow state (Choi, et al., 2007; Konradt, et al., 2003; Liao, 2006; Liu, et al., 2011; Shin, 2006) or may follow by several months after a given activity has occurred (Choi, et al., 2007; Liao, 2006). This situation limits conclusions about whether flow does influence learning in CMEs.

The fundamental question remains whether flow is experienced during CMEs generally and CMLEs (computer mediated learning environments) more specifically, and how the experience of flow may affect learning. Given the lack of consensus about how flow occurs in CMLEs, conclusions about whether CMLEs allow for flow or at minimum, learner engagement, are not readily drawn. Further, the body of literature concerning CMLEs and flow spans diverse disciplines that tend to perpetuate, within discipline, a particular conceptualization of the flow construct. In this paper, we review these issues and make suggestions for clarifying the flow construct as linked to learning outcomes within CMLEs.

2 FLOW AND ITS CHARACTERIZATION

Flow refers to a state of optimal performance whereby individuals feel in control of their behavior while engaged in motivating activities, and report extreme enjoyment or self-transcendence (Csikszentmihalyi, 1988). According to Csikszentmihalyi (1988), flow is experienced across diverse domains and activities, is all-absorbing, and seemingly automatic despite occurring during cognitively demanding tasks (Csikszentmihalyi, 1988). He further noted that those experiencing flow were more likely to re-experience it. Therefore, flow is best characterized as cyclical, whereby its attainment is positively correlated with the desire and likelihood of re-attaining it.

According to Csikszentmihalyi (1988; 1990), flow is comprised of nine major components reflecting the general categories of *antecedents*, *experiences*, and *effects or consequences*. One antecedent includes a balance between perceived skills required to complete an activity and optimal challenge whereby the activity is neither too easy nor too difficult. When one's skills are low and challenges posed by the task are too easy, an individual may experience apathy. If one's skills are high, but challenges posed by the task are too easy, an individual may experience boredom. Similarly, when one perceives one's skills as insufficient given the demands of the tasks, the individual may experience anxiety and abandon the task. Accordingly, ideal flow situations are those in which the challenges become progressively difficult as one's skills improve. Two further antecedents include a clear, attainable goal and unequivocal feedback from the situation.

Aspects of the flow experience entail the merging of action and awareness, which is accompanied by focused concentration that culminates in the paradox of control (Csikszentmihalyi, 1988). Here, the individual feels in control of his actions during a task, despite a seeming automaticity and effortlessness to his behaviors. The three flow effects include the loss of self-consciousness, the transformation or distortion of time, and a resulting enjoyable experience.

Csikszentmihalyi first examined flow within the context of athletic performance (Csikszentmihalyi, 1988; Csikszentmihalyi, 1990). For example, while interviewing high-achieving athletes about their performance in their respective sports, Csikszentmihalyi (1988, 1990) noticed that each described key accomplishments in similar ways: the loss of self-consciousness, the sensation of being carried or flowing on a current, and the feeling of being present in the moment despite exposing their bodies to stressful physical circumstances. Participants also reported feeling compelled to re-engage in these activities when they accomplished their goals, if only for the opportunity to achieve new goals and the self-fulfillment that accompanied their success. For example, Sato (1988) found that Japanese adolescents' motorcycle riding produced positive feelings of well-being among those engaged in the activity, a sense of community with fellow riders, and pride from applying their skills to the challenges of the rides.

3 MEASUREMENT OF FLOW

Since the late 1970s, the standard technique for measuring flow had been the Experience Sampling Method (ESM). This tool, first used by Csikszentmihalyi and colleagues (Csikszentmihalyi and Larson, 1987; Csikszentmihalyi, Larson, and Prescott, 1977), was designed to allow real-time measurement of flow experiences. Specifically, individuals were given paging devices that randomly "beeped" during a given interval of time. When the devices beeped, participants were to stop what they were doing and answer questions about the activity in which they were currently engaged. For example, participants were asked what they were doing, where they were doing it, their emotional state, involvement in the activity, perceptions of activity challenges, perceptions of their skills to meet these challenges, interest and motivation to engage in the activity, concentration levels, their sense of self-consciousness, and control. Csikszentmihalyi and LeFevre (1989) found, via this technique, that individuals tended to report experiencing flow more often while on the job than during leisure activities despite their greater motivation to engage in leisure activities. Notably, those who were more engaged in a given activity when they were beeped reported happier feelings, greater creativity, concentration, and satisfaction than those who were less engaged. Other researchers using ESM and its derivations have since documented flow in diverse activities across cultures including daily labor, educational settings, web navigation, electronic gameplay, and computerized simulations (Carli, Delle Fave and Massimini, 1988; Chen, et al., 1998; Csikszentmihalyi and Csikszentmihalyi, 1988; Csikszentmihalyi, 1990; Larson, 1988; O'Broin and Clarke, 2006; Shernoff et al., 2003).

4 FLOW IN TRADITIONAL LEARNING ENVIRONMENTS

Flow also has been studied in diverse educational contexts. For example, Shernoff, et al. (2003) examined flow in the context of student engagement in classroom activities using data from a three-year longitudinal study of 526 10th and 12th graders. These students participated in discussions that were either teacher-led or student-led and required skills and challenge levels that varied from low to high. Participants then completed surveys concerning aspects of flow such as engagement, attention, motivation, and enjoyment, with regard to the activities completed in class and their perceived performance in these activities. Students' perceptions of high challenge and skill levels were associated with greater engagement in their coursework than when they perceived lower challenge levels. When experiencing flow, students reported greater interest, concentration, and enjoyment than those not experiencing flow (Shernoff, et al., 2003).

Larson (1988) also found that characteristics of flow correlated with better research papers produced by high school students for their junior-year English class than when these characteristics were absent. In his study, students were to write 10-page papers over the term, and to review and to revise their work based on teacher feedback before submitting final drafts. Larson (1988) compared students' survey responses about their emotional states while writing their essays with their essay grades to determine how flow characteristics predicted their performance. Students who demonstrated aspects of flow, as reflected by enjoyment in the activity, also demonstrated effective self-regulation strategies to stay on task, and achieved their goal of writing well-structured and well-researched papers according to their teachers. Students who experienced flow, regardless of time spent on the task, were more creative, more efficient and received higher grades than peers who did not cite flow. Further, those who did not demonstrate aspects of flow set expectations that were unrealistically high, were more anxious about their goals for completing their papers, and received poorer grades than their counterparts who reported flow.

Collectively, these findings show that in traditional learning environments students who achieve flow as opposed to those who do not, are more engaged in and attentive during their schoolwork (Shernoff, et al., 2003), more successful at achieving their academic goals (Larson, 1988), better at employing self-regulation strategies (Larson, 1988), more likely to show gains in self-esteem following the activity (Shernoff, et al., 2003), experience greater enjoyment (Shernoff, et al., 2003), and report less anxiety about their schoolwork (Larson, 1988). Studies eliciting these findings, however, are not grounded in all original nine variables that Csikszentmihalyi cited as requisite for the flow experience. This situation reflected a situation whereby researchers made selective choices about which variables to include in their investigations of the flow experience. Among the variables selected most often were the balance of perceived skills to perceived challenges and perceived control. Among the variables most often excluded were feedback, time distortion and loss of self-consciousness. The selective addition and deletion of components of Czikszentmihalyi's model was notably evident in the literature concerning flow in the context of CMLEs as discussed below.

5 EXAMINATION OF FLOW IN CMLES

Given educators' increasing interest in online learning, research examining flow in the context of CMLEs (Chen, et al., 1998; Ghani, 1995; Voiskounsky, 2008; Webster, Trevino and Ryan, 1993) has become more salient. Across this growing body of work, very clear distinctions in the operationalization of flow, the timing of its assessment, and the characterization of learning have emerged. Specifically, flow has been described via characterizations that reflected all, some, or none of Csikszentmihalyi's original formulation (1988; 1990). Second, flow has been assessed at variable times intervals such as during learning activity sessions (consistent with Csikszentmihalyi's ESM approach) or after, sometimes with significant delays. Finally, although researchers have often claimed to have measured learning via content or skills acquired after a given activity (reflecting a direct learning measure), in most if not all studies as reviewed below, learning has been assessed via attitudes about the activity or one's skills (reflecting an indirect learning measure). These discrepancies have ramifications for understanding the linkage between flow and learning within CMLEs and begin with defining the flow construct.

5.1 Divergence in the Operationalization of Flow

Researchers who first studied flow in the context of CMLEs did not see Csikszentmihalyi's (1988; 1990) original formulation as applicable. For example, Hoffman and Novak (1996) built a model to examine flow in the navigation of consumer web sites that started with Csikszentmihalyi's nine characteristics and then also incorporated extrinsic motivation, as demonstrated by goal-directed search (where search referred to those conducted while navigating a given website); intrinsic motivation, or non-directed search; users' level of involvement in the task at hand, interactivity of the medium, vividness of the site, and telepresence or the "mediated perception of an environment" (see Steuer, 1991, p. 76). According to Hoffman and Novak, the attainment of flow was linked to increased learning, perceived behavioral control, willingness to explore (in their case, websites), and positive subjective experiences. They demonstrated this in studies examining participants' exploration of a consumer website (Novak, et al., 2000), whereby reported experiences of flow were significantly, positively correlated to respondents' perceived skills, perceived challenges of browsing the web site, telepresence, and to the interactive speed of the web site.

Despite only a few variables being shown to link directly to flow, researchers would continue to draw from and test the work of Hoffman, Novak and colleagues (Hoffman and Novak, 1996; Novak, et al., 2000). Some of these researchers who drew on Hoffman and Novak's (1996) work used predictors that seemed unique to CMEs, such as interactivity (Liao, 2006) and telepresence (Shin, 2006). For example, Liao (2006) found that within a distance learning course, interactivity was more predictive of flow than undergraduate participants' assessment of the balance of skills to perceived challenges; a finding that contradicted the accepted notion that the balance of skills and challenges is the best predictor of flow (Chen et al., 1998; Konradt, et al., 2003; Massimini and Carli, 1988; Pearce, Ainley, and Howard, 2005). Shin (2006) incorporated telepresence into a factor analysis to clarify how the flow antecedents of perceived skills, perceived challenges, and clearly defined goals, contributed to the flow experiences of enjoyment, telepresence, focused attention, engagement and time distortion within online coursework. The findings showed that these five experience factors accounted for nearly 60% of the variance in explaining flow. Further, flow was significantly positively correlated with the balance of skills and challenges and overall satisfaction with online courses.

Others would omit variables, such as the perceived balance of skills and challenges that were common in flow studies and instead examined the appeal of the activities themselves. For example, Ryu and Parsons (2012) assessed the link between flow and learning using a mobile device application via a seven-question Likert scale drawing on two variables from Csikszentmihalyi (1990) to predict flow, which were cognitive curiosity, and intrinsic interest, and added risk-taking behavior, or attempts to explore aspects of the learning environment not required by the task instructions. Flow was indirectly linked to learning through each of these three predictors demonstrating participants' voluntary willingness to explore the environment further, greater importance given to the activity, and more motivation to learn.

Still other researchers examined flow with respect to only one of Csikszentmihalyi's (1988; 1990) original nine predictors of flow; the balance of perceived skills and perceived challenges (Csikszentmihalyi and LeFevre, 1989; Konradt, et al., 2003; Liu, et al., 2011; Pearce, et al., 2005). For example, Liu, et al., (2011) examined flow and learning through use and acquisition of problem-solving strategies among 110 first-year university computer science students constructing railway system simulations follow lecture or lab activities. The authors hypothesized that students in flow would show better problem-solving strategies than students who were anxious or bored; essentially, the antithesis of flow. Findings indicated that flow was more likely to occur when the students were actively engaged in building simulations than passively involved in the lectures. Specifically, when building simulations, over 55% of students achieved flow; 21% of students achieved flow when attending lectures. Liu, et al., (2011) offered a unique contribution to the literature in that they demonstrated that flow was correlated to a direct learning outcome, namely that participants in flow appropriately transferred successful problem-solving strategies to new situations more often than those who did not achieve flow. However, this finding was only marginally significant.

Choi, et al., (2007) assessed flow using participants' self-report of whether they had experienced it, their ratings of its frequency, and its intensity. Participants were asked to answer survey questions two to three months following the end of the course to determine whether flow impacted individuals' self-efficacy with technology while using an e-learning system. Students' self-reports of flow were significantly, positively correlated with their attitudes towards or satisfaction with e-learning and with technology self-efficacy.

Notably, one set of researchers (Pearce, et al., 2005) evaluated flow in two ways; the first entailed a situated measurement that assessed flow immediately after each of seven learning activities by asking participants to rate their perceived skills to meet the perceived challenges (Massimini and Carli, 1988; Konradt, et al., 2003). From these seven skill/challenge ratios the researchers tallied a final, in-situ score for flow. Pearce et al., (2005) also assessed flow a second way using a post-hoc questionnaire following all seven activities. Flow was operationalized by the variables of control, enjoyment and engagement. Surprisingly, the post-hoc measure of flow did not correlate with the in-situ measure of students' flow states. This finding was perplexing as the balance of perceived skills to perceived challenges as used in the in situ measure, and control, enjoyment, and engagement from the post-hoc measure are all variables that have been established as predictors of flow and should have yielded a positive correlation. Therefore, the authors re-examined participants' post hoc reports of flow and found that they were correlated with the most memorable of the seven activities that participants had just experienced. When the researchers were comparing the post-hoc measure to a summed total of the seven distinct in situ measures they had conflated flow and non-flow moments. Thus, the predictors of flow were less important than the timing of the flow assessment to the supposedly flow-inducing activities.

5.2 Measurement and Timing of Flow within CMLEs

The timing of flow measurement is critical to the accuracy of individuals' self-report. If it is too delayed, memories fade leaving reports of the experience in doubt. In ESM, participants' perceptions of flow states are assessed as soon as they receive the alert to report on their state. However, ESM has been criticized because it removes participants from the state to be assessed (Weber, et al., 2009). A survey of the literature indicates that researchers have assessed flow using both in-situ and post-hoc measures. For example, Pearce, et al., 2005 examined flow in-situ, following each of the seven potentially-flow inducing activities, and after the entire set of seven learning activities. Other researchers have assessed flow in non-situated ways and with significant time delays. In fact, Ryu and Parsons (2012) assessed flow days after the flow-inducing activities occurred and Choi, et al. (2007) and Liao (2006) did so months after these activities ended.

Variants in the timing of flow may be an artifact of researchers' efforts to adapt measurement of flow to web-based environments. For example, Chen et al, (1998) adapted ESM for the web such that a survey assessing flow would appear directly on the screen on which the respondents already were viewing. In their study, their flow conceptualization was consistent with that offered by Csikszentmihalyi. As part of their investigation, they designed a questionnaire to "pop up" randomly and frequently during web browsing sessions as participants navigated different sites. The researchers found evidence of flow in users' experiences, particularly, when the users perceived themselves as able to navigate a given site.

Researchers also have adapted ESM for use within learning activities occurring on computers or within CMLEs. For example, O'Broin and Clarke (2006) adapted the Chen, et al. (1998) pop-up web survey to design a computer-based and mobile application which recorded students' assessment of their perceived skills, perceived challenges; clarity of the activity's goals; understanding of feedback; meaningfulness of the activity; amounts of concentration; and feelings of control. Findings showed that participants were in flow 81% of the time when engaged in a given task.

Capturing the flow state as close in time to when it likely occurred is the goal of many studying flow (Chen et al, 1998; Csikszentmihalyi and Lefevre, 1989). Conceivably, this is because measurement accuracy should be higher when more closely situated to the flow experience. For example, Pearce et al. (2005), in the study described above, noticed that participants who did well on the learning activities demonstrated skill growth as the scaffolded challenges increased. Specifically, the skill/challenge ratios following the first activity, the fourth activity (which was highly-challenging and thus, presumably memorable), and the sixth and seventh activities significantly correlated with the post-hoc measure of flow. The authors concluded that primacy effects, recency effects, and highly salient events, such as greatly challenging tasks, predominated participants' overall assessment of their experiences reporting their flow states after all activities had been completed. This conclusion highlights the importance of contextualizing flow measurement to particular moments in time and not generally as flow may vary during the course of an activity or over the course of a set of related activities.

Additional criticisms of flow measurement include assessing flow as related to an activity in general and not to a specific moment when flow may have occurred (Weber, et al., 2009). For example, Shin (2006) and Liao (2006) assessed students' flow states as related to perceptions of their online coursework overall rather than specific activities where they may or may not have been in flow. The use of ESM and adapted ESM techniques has greatly improved flow measurement by allowing researchers to assess flow immediately after having experienced it (Csikszentmihalyi and Larson, 1987; Csikszentmihalyi and LeFevre, 1989). However, studies that utilized adapted ESM techniques did not examine flow's link to learning (O'Broin and Clarke, 2006) and studies that utilized other forms of in situ measurement of flow did not establish links to direct learning outcomes (Pearce, et al., 2005). There is inconsistency about what flow is and despite clear recommendations in the research specifying that flow should be measured as close in time to the supposedly flow-inducing moments, researchers measure flow in non-situated ways and with significant delays following the activities. Therefore, conclusions about flow's linkage to learning are dubious.

5.3 Flow Linkages to Learning Outcomes within CMLEs

Findings that examine the linkage between flow and learning outcomes, especially direct learning outcomes, are limited. For example, Liu, et al., (2011) as noted above, demonstrated flow's link to successful use of problem-solving strategies. However, these researchers assessed students' perceptions of flow following a six-week lecture period, and later following a two-week period of building simulations thereby conflating flow and non-flow moments within each assessment and neglecting appropriate measurement of the construct. Therefore, this situation compromises conclusions about whether it was flow that was linked to learning, or another aspect of the instructional situation unrelated to participant's flow levels.

Far greater evidence of flow's linkage to indirect than direct learning outcomes is reflected in the literature. For example, flow has been shown to yield greater satisfaction with learning (Choi, et al., 2007; Liao, 2006; Shin, 2006), self-efficacy within the medium (Choi, et al., 2007), intentions to engage in the learning environment again in the future (Liao, 2006), exploratory use of the environment (Liao, 2006; Ryu and Parson, 2012), and motivation to learn and involve oneself in the activity (Ryu and

Parsons, 2012). Compromising the linkage between flow and indirect learning in these situations is that flow was assessed either independent of a given learning activity (Liao, 2006; Shin, 2006) or long after the activity concluded (Liao, 2006; Ryu and Parsons). A consistent definition of flow and a situated and timely measurement of flow's impact on learning outcomes would reduce doubts about claims of flow's linkages to learning,

6 CONCLUSIONS

The fundamental set of questions that emerges from the literature is whether flow occurs within CMLEs, and if so, how best to measure it and facilitate it so as to impact learning. The promise of flow is that it is all-absorbing engagement in a task and it motivates individuals to engage in an activity, to exceed their current skills, and to continually increase their expertise in this domain. This situation is desirable in both formal and informal education contexts.

However, characterizations of flow in CMEs and CMLEs have been inconsistent. Similarly, researchers' measurement of flow have deviated widely from Csikszentmihalyi and colleagues' (Csikszentmihalyi and Larson, 1987; Csikszentmihalyi, et al., 1977) goal to capture the flow experience as close in time to its occurrence. As noted above, many researchers have assessed flow long after its occurrence has passed.

As part of our efforts to clearly identify trends in these differing definitions of flow and its measurement as linked to learning within CMLEs, we suggest the use of meta-analysis, as currently being undertaken in our work. The goal of our meta-analysis is to extensively examine the pool of relevant studies to determine if the divergent methods of defining and measuring flow demonstrate consistent impact on direct or indirect learning outcomes. It is anticipated that given the diversity of flow characterizations and measurement that a homogeneous effect, which would signify one universal impact of flow on learning across all studies, is highly unlikely. More likely, the overall meta-analytic effect size will demonstrate heterogeneity, whereby some flow characteristics might demonstrate stronger links to direct and indirect learning outcomes as compared to other flow characteristics that demonstrate weaker links to learning.

Given that learning might be influenced more by a small number of flow characteristics, such as the balance of skills to challenges and the interactivity of the CMLE, the meta-analysis would recommend flow characteristics and combinations of those characteristics that demonstrate the kinds of learning gains that are possible when learners actually achieve the flow state. Further, certain situated measurements of flow might demonstrate greater occurrence of flow, or increase the certainty that flow actually occurred as compared to significantly delayed measurements of flow that might produce further doubts to flow's association with learning. Since flow is difficult to capture the more time has elapsed and the more general the measurement is to flow moments, even without the benefit of our meta-analysis, one may conclude that researchers should avoid non-situated and delayed measures of flow.

By offering an operationalization of flow that demonstrates its ability to impact learning within CMLEs and situating its measurement close in time to its occurrence, this meta-analysis would offer a starting point for more consistency in this area of the literature. Thus, examining flow's link to learning outcomes within CMLEs could be more easily compared across studies because when flow is discussed it is certain that there is a consistent definition and reliable measure of flow.

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Exploring the Gender Effect on Cognitive Processes in Program Debugging based on Eye-movement Analysis

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Abstract: This study addresses the gender differences of cognitive processes involved in program debugging. In the experiment, twenty-five participants were asked to find bugs in the test programs. Eye-movement analysis was employed to track the students' gaze paths while they traced and tried to debug the programs. Cognitive processes were then obtained by employing sequential analysis of gaze data to investigate the significant sequences of attention areas. Cognitive processes of different genders were investigated by comparing the tracing sequences of program debugging. The experimental results show that both genders had limited working memory capacities for debugging the iterative program with complex computation. But females needed more manual calculation for the recursive program in this study. For the iterative structure, females tended to grasp the program requirements and then trace into the major part of the program, while males traced the change of output value according to the logic of the iterative statements. For the recursive problem, females traced the flow of recursive induction and the stop condition to execute the program and find bugs, while males traced the recursive function in a more leaping way. This study leaks the gender differences of cognitive processes in program debugging, based on which instructors/researchers can develop adaptive computer programming instruction for students of different genders.

1 INTRODUCTION

Many instructors/researchers investigated how to effectively and efficiently develop students programming skills. However, it is still challenging in the field of computer science education (Costelloe, 2004). The most challenging thing for novice programmers is to locate and resolve bugs (Lahtinen et al., 2005). Novices usually felt frustrated when they had to find bugs because their knowledge about programming was fragile (Perkins and Martin, 1986). Some research discussed programmers' debugging behaviors and found that novice programmers debug programs in a trial-and-error manner without comprehending programs so that they usually cannot resolve errors successfully (Fitzgerald, et al., 2008). Thus, investigating factors of students' cognitive processes in debugging programs is one of critical keys to improve their programming skills. However, cognition is a very complex process. Traditional research on cognition often conducted interviews and paper tests (Chen et al., 2010), but the results of these methods might be affected by missing memory, the exactitude of introspection, and unconscious social desirability. More than 80% of cognitive processes are obtained through vision (Sanders and McCormick, 1987). Eye movements are not smooth and individuals do not gaze on just one point of a visual field; they switch between fixation and saccadic eye movements in a very short space of time. Such complex brain activities underlie the concept of cognition. Through the process of eye-tracking, it is possible to obtain data regarding the amount and moment of eye fixation, saccade, gaze duration, regression, skipping, and refixation in an area of interest (AOI), which in turn can help us understand the cognitive processes occurring simultaneously. Eye movements detected by eye-trackers can provide much information regarding visual cognitive processes (Just and

Carpenter, 1984) and has been used to investigate creativity, learning, reading, teaching, affection, and problem solving. In a previous study, researchers applied eye-tracking to capture visual attention strategies and to conduct a detailed account of visual attention during a debugging task (Bednarik, 2011). Another study by Bednarik et. al. (Bednarik, Myller, Sutinen, and Tukiainen, 2006) reported that gaze can reflect the thinking mode of a subject, represent their interest level, and the importance of each visualized area. However, they did not find any correspondence between program debugging and the mental model used.

In this study, we investigated the gender effects on the cognitive processes of program debugging, which can give suggestions to instructors for design adaptive instructional strategies for different genders.

2 METHODOLOGY

2.1 Participants

The participants were twenty-five subjects (13 males, 12 females) of the Department of Computer Science in a university in North Taiwan. They studied programming in C for at least one year. None of the subjects had major psychological or psychiatric disorders that may affect the experimental results.

2.2 Procedure

The C language was utilized in this study. Participants were provided with 2 100-lines C programs (one was the iterative structure and the other was the recursive structure), each had three semantic or syntactic bugs. The time limit for each problem was 10 min. The subjects had to try to find all bugs by watching the source codes without using program development software. After they finished debugging the codes, they then had to explain the logic and the purpose of the programs in an interview in order to assess whether they understood the programs successfully had to try to find all bugs by watching the source codes without using program development software. After they finished debugging the codes, they then had to explain the logic and the purpose of the programs in an interview in order to assess whether they understood the programs successfully.

2.3 Data Collected

The Eyelink 1000 eye-tracker was employed to record participants' program debugging paths. The viewing distance was approximately 86 cm and the screen resolution was 1024 × 768. The gaze data was at first down sampled to obtain quantized gaze sequences. Sequential analysis (Bakeman, 1986) was then further employed for data interpretation and simplification. This algorithm can analyze how a set of complex probabilities behaved when it is applied repeatedly over time based on Maximum likelihood estimation. After sequential analysis, students' cognitive processes could be extracted.

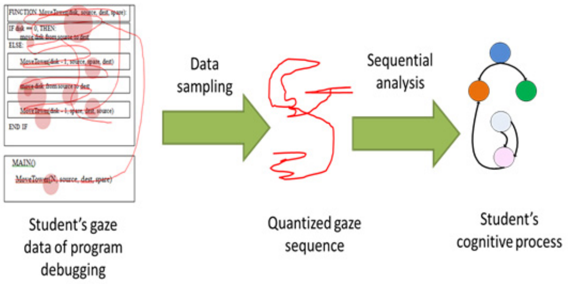
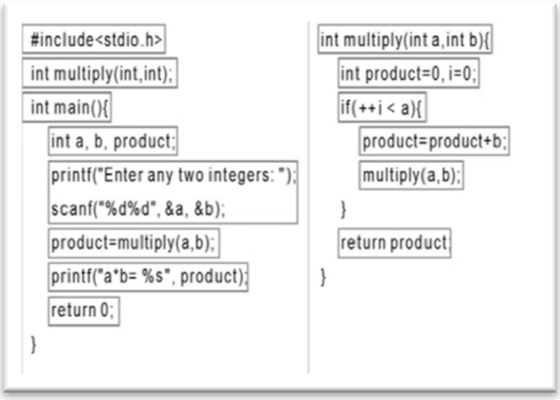


Figure 1: System overview.

The whole experimental procedure, including the interview was recorded with a video camera to avoid loss of information. We also provided the subjects with the function of free drawing on the screen so that they could write down their thoughts or computational processes. The Region of Interest (ROI) was decided according to the logic of the program, e.g., variable definitions, I/O statements, conditional statements, function calls, computations in the function, and the note area. Figure 2 presents an example of a test program and the corresponding ROIs (each ROI was labeled with a block).



```
#include<stdio.h>
int multiply(int,int);
int main(){
    int a, b, product;
    printf("Enter any two integers: ");
    scanf("%d%d", &a, &b);
    product=multiply(a,b);
    printf("a*b= %s", product);
    return 0;
}
```

```
int multiply(int a,int b){
    int product=0, i=0;
    if(++i < a){
        product=product+b;
        multiply(a,b);
    }
    return product;
}
```

Figure 2: One example of ROIs.

3 RESULTS AND DISCUSSION

3.1 The Iterative Problem

The experiment results for the iterative program, as illustrated in Tables 1, show that when debugging the iterative program, both males and females had the significant sequence of

- Note area→Note area

This implies that both genders could not manipulate computations completely mentally while tracing the program and needed the note area to assist program tracing. The reason might be that their working memory capacities were not enough to trace the program because mental arithmetic is constrained by working memory (Adams and Hitch, 1997; Mackintosh and Bennett, 2003). Female students had the following additional sequences:

- Variable definition→I/O statement
- I/O statement→I/O statement
- I/O statement→Inner loop condition

That is, females paid much attention to the basic definitions and program requirements, which are the major step to comprehend the program (Chen, 2007). Males had the additional sequences:

- Computation in the conditional statement→ Variable definition→Conditional statements for the output value
- Output→Output

They spend more time tracing the value changes according to the logic of the iterative statements of the loop. Previous research (Marzieh, Dave, & Colin, 2007) argued that the most common mistakes made by novice programmers occur in the loop statements. Therefore, male participants in this experiment also considered the bugs might occur in the loop.

3.2 The Recursive Problem

In the experiment of the recursive program, females had the significant sequences (as presented in Table 2):

- Recursive function name→Variable definition in the recursive function → Conditional statements in the recursive function
- Conditional statements in the recursive function → Conditional statements in the recursive function
- Computation in the recursive function → Computation in the recursive function → Recursive call
- Note area→Note area

The results show that females often found bugs in recursive statements and followed the recursive logic, which compiles with Sabah's research (2012) indicating that students have to trace the flow of recursive induction and the stop condition to execute the program and find bugs. However, males tended to confirm the program requirements at first by seeing the I/O statements. Their significant sequences were:

- I/O statement→I/O statement
- Return value of the recursive function → Computation in the recursive function
- Recursive function name→Variable definition in the recursive function

Table 1: Results of the sequential analysis for the iterative program debugging.

z	Variable definition		I/O statement		Outer loop condition		Inner loop Condition		Computation in the conditional statement		Conditional statements for the output value		Output		Note area	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
Variable definition	1.84	-0.59	2.54*	-0.5	-0.6	0.54	0.99	1.56	0.07	-1.35	0.11	2.88*	-0.68	-0.3	-0.84	0.17
I/O statement	0.52	0.28	2.57*	1.87	0.17	-1.79	3.13*	1.37	1.29	-0.24	-1.36	-0.65	0.02	-0.17	-2.73	-0.52
Outer loop condition	0.15	-1.17	-0.35	-1	0.6	1.51	1.96	1.66	1.03	0.64	-0.4	0.84	-0.11	-1.47	-0.39	-0.21
Inner loop Condition	-0.29	-0.64	1.33	0.7	1.96	-0.18	1.89	1.82	0.98	0.34	-0.73	-0.32	-0.18	0.24	-1.81	-1.22
Computation in the conditional statement	-0.52	2.36*	-1.2	-0.24	0.11	0.64	0.19	-0.3	0.13	-0.87	-0.9	-0.81	1.71	-0.43	-0.17	0.24
Conditional statements for the output value	-0.95	-0.81	0.12	-0.65	-0.4	-0.4	-0.73	-0.85	-0.25	-0.27	0.3	3.32	1.9	1.5	0.6	-0.49
Output	1.48	-0.3	0.52	-0.57	-1.24	-1.03	-1.14	-1.25	-1.39	1.08	1.11	1.5	0.83	2.5*	-0.96	-0.72
Note area	-1.37	-0.92	-1.99	0.49	-1.21	-0.21	-1.81	-0.29	-0.83	-0.23	2.35*	-1.28	0.24	-0.72	3.56*	2.03*

*$p < 0.05$.

Table 2: Results of the sequential analysis for the recursive program debugging.

Z`	I/O statement		Recursive function name		Variable definition in the recursive function		Conditional statements in the recursive function		Computation in the recursive function		Recursive call		Return value of the recursive		Note area	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
I/O statement	-0.75	2.2*	-0.66	1.19	0	-1.39	0.85	-1.88	0.31	-0.27	-0.15	-1.26	0.66	0.46	-0.42	-0.59
Recursive function name	-0.66	-0.43	-0.59	-0.52	2.5*	2.72*	0.46	-0.94	-0.23	-0.42	-0.96	0.2	-0.64	-0.83	-1.1	-1.4
Variable definition in the recursive function	1	-0.66	0.24	-0.06	-0.59	-1	2.06*	1.03	0.68	1.03	-1.45	1.25	-0.97	-0.93	-1.05	-1.57
Conditional statements in the recursive function	-1.36	-0.27	0.46	-0.42	0.39	2.41*	2.85*	0.43	0.32	0.43	0.61	0.51	-1.31	1.12	-1.8	-1.17
Computation in the recursive function	-1.27	-1.88	-1.12	-0.42	1.86	0.56	-1.43	1.45	2.08*	0.77	2.58*	0.51	-0.4	1.12	-0.17	-1.17
Recursive call	1.71	-1.26	1.14	-1.32	-0.75	-0.8	-0.94	1.02	0.93	1.02	1.68	-0.6	-0.08	0.33	-1.78	-0.02
Return value of the recursive function	-0.72	0.46	-0.64	-0.83	-0.97	-0.93	-1.31	1.12	-1.22	2.71*	1.85	-0.85	-0.7	-0.54	2.18*	-0.9
Note area	`0.39	1.67	-1.1	-0.68	-1.05	-1.57	-1.35	-0.22	-1.62	-1.17	-0.65	-0.02	3.87*	0.21	2.91*	0.49

*$p < 0.05$.

- Conditional statements in the recursive function →Variable definition in the recursive function

Males seemed to trace the recursive function in a leaping manner and did not pay equivalent attention to all recursive components. They traced the value changes according to the conditional statements and variable definitions in the recursive function. In addition, they did not use the note area as often as females did. It seems that males did not feel the limitation of their working memory for solving this recursive program.

4 CONCLUSIONS

This study addresses the gender effects on cognitive processes involved in computer program debugging based on eye-movement analysis. The naïve gaze data was analyzed by sequential analysis to find the sequences of cognition. The findings show that both genders had limited working memory capacities for debugging the iterative program with complex computation. But females needed more manual calculation for the recursive program in this study. For the iterative structure, females tended to grasp the program requirements and then trace into the major part of the program, while males traced the change of output value according to the logic of the iterative statements. For the recursive problem, females traced the program based on the recursive logic to find bugs, while males traced the recursive function in a more leaping way. The evidence of gender differences in cognitive processes of program debugging can help understand more about cognition of programming and design suitable programming instruction for different genders.

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POSTERS

Blended Learning and Consulting for Resource Limited Enterprises

The Case of a Prototyping, Production and Logistics Service Centre at a Business Incubator in Brazil

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Abstract: Start-ups and other innovative, but small enterprises – such as those associated with business incubators - usually have financial limitations that hinder their attempt to properly address product and service lifecycle challenges. Some of these challenges regard aspects of prototyping, production and logistics (PPL). Inability to properly address PPL challenges sometimes delays time-to-market too long, causing the company to fail. In order to assist companies to efficiently address PPL challenges, a low-operating-cost, risk-seeking, PPL Service Centre is being planned for an incubator in Brazil. In order to account for financial restrictions, the Centre's operations are to be based on blended learning pedagogy but expanded to encompass provision of consulting services and access to laboratory and workshop' facilities. Creating such a Centre is timing consuming and resource intensive. Therefore it must be demonstrated that the investment will be worthwhile. A small investigation has been conducted which has looked into the PPL needs of technology-based enterprises associated with the incubator. The results have been used to specify and initially operate the Centre to allow for a more blended style in service provision. This paper summarizes the investigation, its results and the Centre's initial operation and preliminary achievements.

1 INTRODUCTION

Innovative but "micro" and small enterprises (MSEs) have budgetary restrictions that limit their capacity to invest in staff training and consulting services to address barriers and problems throughout the life cycle of their new products or services. This is true everywhere (Tiwari and Buse, 2007) but appears to be the norm in emerging markets such as in Brazil. Indeed, "need of investments" appears frequently in surveys of technology-based MSEs by the Technology Park Foundation of the State of Paraíba (www.PaqTc.org.br) in Brazil.

Available funding to Brazilian MSEs tends to be destined for innovation, research & development (R&D) activities. Albeit their importance for market success, activities later on the lifecycle, such as prototyping, production, logistics, marketing (including market acceptance tests of prototypes) and sales are historically allotted little investment. Over the years, PaqTc has observed that a significant percentage of failures of incubated MSEs can be attributed to inadequate attention to and actions in prototyping, production and logistics (PPL) in anticipation to or in support of marketing & sales (M&S) operations.

To reduce the failure rate of its MSEs and to alleviate their difficulty in securing investments for PPL, PaqTc with sponsorship from the Brazilian Research Council (CNPq) decided to plan and operate a PPL Service Centre that has low fixed costs and offers accessible and effective solutions to PPL problems. This position paper presents the planned centre whose service and operations extend Blended Learning (BL) principles to encompass and mix training, consultancy and workshop practicing.

BL refers to an instructional environment where interactions between instructors and trainees take place face-to-face (such as in a classroom where the interactions are mostly "synchronous") and using Information and Communications Technology (ICT)-based facilities (for asynchronous interactions, such as participating in a Web course through a computer or smart phone). ICT-based facilities allow the trainee to have some control over time, location, sequencing and pace of the instruction he or she receives. In addition, online courses reduce the cost of attending lectures taught by top calibre instructors: (Horn and Staker, 2011) argue that BL grew out of online courses for students who were taking higher level classes in rural K-12 school districts in the US which could not afford bringing a teacher in for face-to-face sessions.

Its potential for cutting costs and instructional media flexibility make BL pedagogy central to modern training programmes. Again quoting from (Horn and Staker, 2011, page 3): “Bleak budgets coupled with looming teacher shortages amidst an increasing demand for results are accelerating the growth of online learning into blended environments… (in order for schools) to do more with less.” On a cautionary note, (Garrison, 2004) points to BL implementation complexity with the “challenge of virtually limitless design possibilities and applicability to so many contexts”.

The context of interest here is that of on-the-job training and problem solving in PPL at start-up or other innovative MSEs under financial duress. Actual problem solving usually requires consultation with experts or practioners besides effective training to grasp and adopt the solution to be implemented. The specialized bibliography brings little insight on applications of BL principles to training on PPL activities let alone to consulting on PPL. This paper contributes by adding to such insight.

This paper proposes a specification for a PPL Service Centre that applies BL principles to facilitate creative and effective solutions to PPL staff training and PPL problem solving through asynchronous learning/consulting networks of risk-seeking experts (in an ad-hoc community of trust) and sharing of (possibly) virtualized (i.e., over-the-internet-accessible) lab/workshop resources and facilities.

The foregoing discussion leads us to posit the research question (RQ) this paper addresses as: “Can BL principles be applied to training and consulting services to address PPL problems effectively and efficiently?” Here, we assume this question will have been answered positively if stakeholders of MSEs which are (potential) clients of the proposed PPL Centre declare they are satisfied the specified services will help them address PPL problems successfully in a cost-effective manner. Since work on the Centre has just started and it is still on-going, the remainder of this position paper only provides a preliminary answer to the RQ. (An answer with greater confidence requires a longer observation interval and work towards that is on-going.)

2 RELATED WORK

Much of the rich bibliography on BL in Conference proceedings (e.g., CSEDU, 2009-12) and in Journal articles (JALN, 1997-2012) reports on applying BL approaches to improve instructional cost and effectiveness in academic, government and corporate settings covering disparate areas such as: Humanities and the Arts (Spohrer and Cassidy, 2012); Engineering (Rouvrais et al., 2005) and related fields – e.g., IT; and, Health (Brandt et al., 2010). The bibliography reveals that BL has become the basis for most employee orientation and training programmes worldwide – see for instance, (Internexia, 2011) for human resource development programmes in general. On the other hand, reports on BL for PPL professionals are almost non-existent. (Manesh and Woll, 2007) describes a conversion effort by Intel Corporation from a classroom to a BL approach for on-the-job training of equipment operators; the authors observe gains in costs, lead time to proficiency and production.

The greater part of the reported work, however, regards experimentation with BL for teaching (JALN, 1997-2012) or by large corporations – such as IBM and Intel in the high tech industry (Bersin, 2004). Albeit some of the works address financial restrictions (Horn and Staker, 2011), the focus is on curriculum design and learning performance.

Also, BL principles appear to have been applied to consulting services sparingly. One exception is (Work Write, 2012) which offers mentoring and consulting on documentation writing – such as software online help. We found no reports on mixing BL and consulting to address PPL problems.

This paper proposes delivering training and consulting coupled with sharing of infrastructure in a more blended style as a way of: i) improving skills in designing and applying solutions to PPL problems by professionals of small enterprises through interactions with a community of invited, specialized consultants and practitioners; and, at the same time, ii) meeting financial restrictions typical of these enterprises. The proposal is a new application of BL in the sense that it includes “blended consulting” and resource sharing through favours from partners. As such, the paper contributes to the literature on BL.

3 NEEDS AND REQUIREMENTS

In 2012-Q2, PaqTc interviewed executives from 7 MSEs in North-eastern Brazil - the region of the

Park's operations since its founding in 1984 and one of the poorest in the country. These MSEs produce hardware bits as part of services for boat building, engineering, home automation, musical devices, sports instrumentation, point-of-sale software and mobile communications – one company has been functioning for over 25 years; another for over 10 years; and the rest, close to 5, having been incubated at PaqTc for the last two. All were selected based on their (eventually) successful PPL experiences and their knowledge of PaqTc's operating limitations. Unstructured interviews (Denzin and Lincoln, 2005) with the executives elicited information on their past and current PPL needs and solution requirements to serve as basis for the PPL Centre specification.

3.1 MSEs' PPL Needs & Problems

According to the interviewed executives, existing courier or transport services sufficed for logistics at least initially, when the company ordered parts to build prototypes or to deliver small production lots. Also, stock keeping did not pose much difficulty. On the other hand, major PPL problems for MSEs arose during construction of prototypes, running pilot tests and organizing production. Prototyping problems were particularly pressing at the start-up stage.

To address these major problems, interviewed executives indicated their MSEs need(ed):

i) "professional advice from expert consultants";
ii) "better knowledge and information about PPL activities, procedures, best practices and tools" – be it to properly contract (and eventually to become independent of) consulting services in i) or to leverage the scarce resources (funding, staff and facilities) available internally or at PaqTc's incubator to better align PPL activities to R&D and M&S goals;
iii) "guaranteed access to performance-and-quality-enhancing prototyping infrastructure such as a laboratory, workshop or equipment";
iv) "information on import procedures and forms" for certain prototype components and parts; and,
v) "a minimal, separate PPL budget" to pay the expenses incurred in tending to the above needs.

The above MSEs' "wish list" clearly indicates the need for blending training with consulting and supporting these blended activities with availability of adequate information and infrastructure. Since it is not usually in the mission of an incubator to tend to need v), the planned Centre would attempt to ease the rest. Although not a requirement, but because of need v), use of multiple media is a natural economic choice for the delivery of services.

3.2 Requirements for the PPL Centre

Requirements for the PPL Centre are derived from the target MSEs' profiles and needs and the incubator's characteristics and goals:

i) Internal preparedness – the overall goal of the PPL Centre's services should be to ensure MSE internal capabilities towards PPL activities.
ii) Comprehensive coverage – services should be provided in areas that impact PPL (not just for PPL proper) in a comprehensive and integrated manner (e.g., training, hands-on experiments, consulting, information & equipment access and technical assistance).
iii) MSE-orientation – Service provision should use material, language, practices, tips, check lists and real-world examples in a way that is accessible and of interest to MSE professionals (e.g., there is little use in examining "production at Intel").
iv) Customization – since PPL problems may vary with industry, target-market, staff and infrastructure specialization, so should the services provided for solving them (i.e., services should be customized to match the client MSE's characteristics and its needs).
v) Minimalist permanent structure – to reduce initial investment and fixed operating costs of staff and infrastructure.
vi) Sustainability – the PPL Centre should charge for services and facilities it offers client MSEs.
vii) Simplicity and affordability – information and services rendered by the PPL Centre should be efficient in terms of clarity and cost, leveraging PaqTc's and partners' resources (facilities, know-how and time), to achieve the most return on the (small) disbursement by the client MSE.

4 A PPL SERVICE CENTRE

The mission of PaqTc's PPL Centre is, first and foremost, to identify and facilitate solutions for prototype building and testing problems faced by start-up, micro and small enterprises. It should also support these enterprises in production and logistics aspects. Complementarily, it should help these enterprises develop internal PPL-problem-solving capabilities. This mission addresses requirement i).

To take care of requirements v) and vi), the Centre's permanent staff is to be kept to a minimum needed to coordinate actions. The Centre's Coordinator should preferably be a well-connected, retired PPL professional who could work part-time to assist MPEs and recruit and engage consultants.

To keep costs low, consultants will be engaged on an expertise, just-in-time, ad-hoc and taskforce-oriented manner. They may be compensated by client MSEs in the form of direct payment for services rendered or through some joint-venture arrangement (stock option, share of results of product being considered, etc.). The Centre is to retain a percentage of consultants' compensation for its financial sustainability.

The remaining requirements drive the Centre's service specification.

4.1 Services

The PPL Centre is illustrated by the rectangle in Figure 1. Initial services are organized into 4 groups: A, B, C and D. BL principles are employed in the service specification of groups A and B and to integrate all four groups. A scaled down approach of collective intelligence – in the sense of harnessing collaboration within a community rather than a "mass" (Glenn, 2009) of expert, multidisciplinary consultants – is used to support service provisioning in groups A and B. New services may be added as needed. Next, each group is discussed in turn.

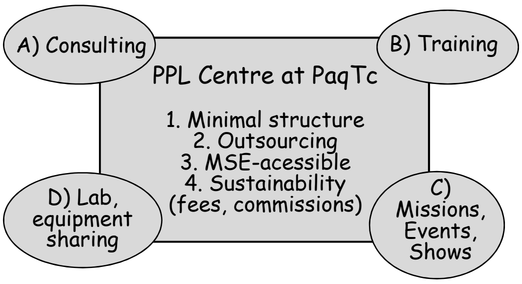

Figure 1: PPL Centre's Service Areas.

A) **Consulting:** includes services for diagnosis and solution of PPL problems and may also encompass complementary (pre-, during- or post-production) consulting on production financing, Project Management or M&S for proof of concept and market acceptance tests, for instance. (Indeed, there may be no point in enhancing production if one has difficulty making sales.) These services are to be supported by:

i) Identification, selection and engagement of expert consultants who may not necessarily be local, but could be anywhere in the country or even in the world. The use of Web conferencing and Voice over IP (VoIP) facilities allows participation of remote consultants *blended* with face-to-face sessions by local consultants and client MSE's professionals in a BL-type environment. Further, consulting activities may be integrated with multimedia training and hands-on equipment practice or via computer simulation ("equipment or lab virtualization") for better leverage of the solutions to be deployed.

ii) Customization and delivery of information and assistance on Supply Chain Management (SCM) for niches of interest (IT, agribusiness…) – for PPL activities, MSEs need to know which and where major suppliers are out there; supplying conditions (quantity, quality, shipping, price, payment, maintenance & support, returns); etc. Delivery of such information may be done using a blend of media, as an e-learning experience or even by underpinning consulting services.

B) **Training:** face-to-face, online or blended-type courses on PPL aspects. Courses may be offered asynchronously or synchronized with consulting activities and may include visits to and exchanges with centres of excellence in PPL (Pisano, 2010) and on-the-job training. Interviewed MSEs have demanded courses on "SCM for MSEs", "PCP for MSEs", "3D Prototype Modeling/3D Computer-aided Design" and "Additive Manufacturing". The SCM course, which has already been offered and evaluated (see 5. Validation), consists of a blended training-consulting solution comprising a 6-hour classroom experience, 8 hours of Web-based activities and a 4-hour web consulting session for on-the-job applications. Participants were taught about SCM concepts and software and integration to Enterprise Resource Planning (ERP) modules. Consulting through Skype and Web video conferencing was brought in to explore ERP issues. Web activities consisted of attending Webinars from software suppliers and discussion with instructors (similarly to blended consulting) and (asynchronously) watching videos on supply chain business processes.

C) **Missions, Events and Shows:** organizing and charging for MSEs' joint participation in business missions and in PPL events and shows, even asynchronously from training activities, is a way to strength and expand PPL professional networking, enhance MSEs' awareness and self-reliance towards PPL activities and reduce costs.

D) **Infrastructure and equipment sharing:** the Centre will arrange for client MSEs to share (rent) PPL labs, workshop and equipment (ex., CNC lathe, 3D printer). It may provide its own facilities (it is setting up an additive manufacturing lab), or collaborate with partner institutions such as local universities or manufacturers which may have PPL lab/equipment spare capacity to share. Sharing postpones capital outlay by MSEs and improves partners' resource utilization (and hence, their ROI). If sharing is done over the Internet, one gets virtualization of workshop activities (e.g., 3D design or additive manufacturing) or equivalently, a *blended* lab (Campoy et al., 2011) or workshop.

5 PRELIMINARY VALIDATION

The proposed PPL Centre is in its early stages of existence. Work to bring its specification closer to market reality and to validate its results is on-going. Preliminary validation efforts however, provide evidence the Centre is (already) useful to MSEs. Evidence is in the form of face validity perceptions of entrepreneurs; evaluation of adequacy and usefulness of training services; and, a case study of provisioning blended consulting services.

5.1 Face Validity Test

We say the PPL Centre has face validity if it "looks like" it is going to lead to a positive answer for the research question (RQ) in section 1.

To test the Centre for face validity, we conducted a survey research (Denzin and Lincoln, 2005) with 22 professionals who represented or worked with over 300 MSEs: the 7 interviewed executives (section 3); 3 professionals from the Brazilian Agency for MSEs (Sebrae); 6 from PaqTc's incubator; and, 5 independent PPL consultants and practitioners. After a presentation on the PPL Centre, the surveyed professionals were asked to comment on the service specification and to indicate what they thought the answer to the RQ would be.

After suggesting minor adjustments to the specified services (incorporated in section 4.1 already), the respondents, unanimously, gave "yes" as an answer (the corresponding Guttman scaling was "Yes", "No" and "Not sure"). Again, note that face validity means that the PPL Centre's blended services "look like" they will work, as opposed to "have been shown to work". Some evidence to the latter is detailed next.

5.2 Evaluation of a SCM Blended Course

Twenty eight professionals from 20 companies of varying sizes (from micro to very large) and industries participated in the BL-based course on SCM (subsection 4.3B) in September 2012. After completing the course and seeing a presentation on the Centre's services, they were asked to answer the research question and to evaluate the SCM course contents and its BL delivery approach.

They were unanimous in responding the research question positively; and, 90% of them said the course contents and blended training/consulting delivery method were "good or very good" (from a "very bad, bad, average, good and very good" set of Linkert options); the remaining 10% opted for "average". Comparison of results from non-BL classes on SCM taught three times previously indicate a higher satisfaction level with the BL-based SCM course mixed with blended consulting: "…more motivating and effective than just the traditional classroom-only or BL-only approach".

5.3 Case Study of Blended Consulting

As a start-up in North-eastern Brazil, RG Electronics (RGe) innovated on special effects pedals for electric guitars. RGe faced difficulties in producing the pedals; difficulties worsened as the company incorporated new products in its portfolio.

An ad-hoc team of 3 independent consultants was assigned to serve RGe. Consultants worked for free (but could have negotiated some sort of compensation). Work sessions were conducted in a blended manner: face-to-face and through the Internet and phone. Early (physical) visits to RGe revealed a recently hired production team with experience in circuit board assembly and tests but no experience nor knowledge on production planning and management. In fact, the production environment was shared with other company's activities and the CEO functioned as PPL fire-fighter frequently, which led to inefficiencies.

The consulting team recommended RGe's production professionals take the "PCP for MSEs" course (subsection 4.3B) and RGe appoint a production manager (other than the CEO). In addition, they also identified other barriers – namely, just-in-time or "sales-synchronous" production; M&S team and partners' compensation policy – which needed addressing to minimize negative impact on production. Financial barriers were eased with sponsorship arrangements that consultants made for RGe to participate in trade and innovation shows in other regions of Brazil – from where the company engaged in regional M&V actions and in contacts with suppliers. Two months after consulting with the PPL Centre, RGe's CEO stated that "the company is now better organized and production is running more smoothly". When answering positively the RQ, he also indicated the "blended services will have a long-lasting, positive contribution to other MSEs in major PPL aspects".

6 CONCLUSIONS AND RECOMMENDATIONS

The main contribution of this position paper was the proposal for blending training and consulting services for effectively and economically dealing with prototyping, production and logistics (PPL) problems at micro and small enterprises (MSEs). Blending is enacted here in the more traditional way of blended learning (BL) which uses multimedia delivery and also in mixing and complementing training with consulting (and vice-versa) and integrating that to information sharing and infrastructure virtualization.

The proposal was investigated as to its adequacy and usefulness to MSEs through a preliminary validation effort. The results are encouraging and albeit their little statistical significance, they suggest that the research question may be answered positively – i.e., that it is possible to specify and provide a blend of training and consulting services with support from BL-like infrastructure virtualization to provide effective solutions to MSEs' PPL problems at low costs.

Upfront economy in executing designed solutions ("use of additive manufacturing" for instance) is made possible by fostering a community of risk-seeking consultants and by sharing (possibly through virtualization and renting) underutilized PPL facilities from partners.

The proposed blended service approach seems naturally more comfortable for clients, better performing and more economical. In the case studied, it was less costly (fewer trips and physical meetings) and faster (no displacement overhead for the involved consultants). We recommend it be tried in incubator settings where MSEs have to be assisted but have a small capacity to pay for services. On-going work will further investigate the validity of this recommendation.

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Knowledge Controlled Mathematical Coaching
Strategies and Results of a Personalized Blended Learning Approach

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Keywords: Mathematical Coaching, Bridging Courses, Personalization, Blended Learning.

Abstract: The mathematical competence of first year students is an important success factor at least for technical studies. As a significant percentage of students do not have sufficient mathematical skills, universities often utilise blended learning courses to increase these skills prior to the start of studies. Due to the diversity of students and their educational backgrounds, individual strategies are needed to achieve the necessary competence for successfully managing their studies. This paper describes our approach at the University of Applied Sciences Ruhr West, where we are using personalized blended learning concepts based on the measurement of individual mathematical competences at the beginning of a coaching process. This is used to gain a better matching between the individual learner level and the adapted learning concepts. We combine individual presence learning groups and a personalized e-learning environment. This environment is adapted based on mathematical skills of each student. It uses individual learning advices, short-term optical feedback and up to date e-learning material in a Moodle-based LMS (learning management system). The coaching concept is approved by the results of summative and formative evaluations.

1 INTRODUCTION

In recent years, university professors in technical studies report decreasing mathematical skills and an increasing diversity of their educational classes.

Since 2002 the mathematical skills at the Universities of Applied Science in North Rhine Westphalia have been tested. The mathematical competence has been evaluated in a standardized mathematical test carried out on the first day of their university education since then.

Ten basic mathematical subjects (e.g. solving equations, quadratics, powers and logarithms, linear equation) have to be solved.

The average value of solved questions is shown in column three of Table 1 (Knospe, 2012).

The already disappointing results of 2002 are continuously getting poorer.

The approach described here utilizes an individual adapted mathematical coaching for each student in order to improve and equalise the qualifications of all students before the beginning of their university education.

Table 1: Results of math-examination before the start of studies.

Year	Number of participants	Number of points (all participants)
2002	2936	3.99
2003	3240	3.86
2004	2741	3.52
2005	1626	3.65
2006	2151	3.66
2007	2593	3.51
2008	2941	3.54
2009	2565	3.86
2010	2493	3.28
2011	3508	3.27

A maximum of 10 points are possible

This paper starts with a section about related work and continues with a description of the architectural approach and detailed information about the implementation, shows results of the evaluation of the system described and concludes with an outlook on planned future work.

2 RELATED WORK

In a blended scenario, our approach combines an online learning course and presence courses that are adjusted to the results of a mathematical test. (Schäfer et al., 2012).

The online course is developed due to the approach of the ARCS-Modell of motivational design by John Keller (Keller, 2010). It uses different elements to gain and keep the attention of the students and to increase the satisfaction, as these are main factors of learner motivation.

We use several concepts of personalized feedback to keep motivation and support the learning outcome. This is similar to concepts of Saul and Wuttke (Saul and Wuttke, 2011). Regarding the results of Jarvis and de Freitas (Jarvis and de Freitas, 2009) on the effects of in-game feedback to the learning transfer improvement, we are using similar feedback mechanisms. In a first pilot study we enriched our interface with a humanoid avatar to improve learning effects as evaluated by Ayad (Ayad, 2010). The learning design considers aspects of diversity as shown by Bhattacharya and Hartnett (Bhattacharya and Hartnett, 2008). To improve the quality of the coaching concept it is embedded in a quality improving process based on a modification of the PDCA cycle (Deming, 1986).

3 ARCHITECTURAL APPROACH

The central idea of our approach is to improve the matching between the individual knowledge of each student and our online and offline teaching strategies. Therefore, each student does a mathematical test with 48 items out of fifteen topics as shown in Table 2.

Table 2: Topics of the mathematical test.

Topic	number of items
Fractions	3 items
Arithmetic with powers and radicals	3 items
Logarithm laws	2 items
Transforming equations	3 items
Solve quadratics	1 item
Build inverse functions	3 items
Elementary power and logarithm values	6 items
Pythagorean theorem	1 items
Definition of trigonometric functions at the triangle	4 items
Drawing of functions	9 items
Symmetrie of functions	2 items
Unit conversions	2 items
Elementary derivatives	5 items
Elementary integrals	3 items

The results are stored in a database and used to adapt the online and presence courses. Further information is presented in (Schäfer et al., 2012).

In order to design the presence courses three clusters of different ability levels are built. Students with low abilities have courses with a duration of three weeks starting in small groups with less than ten participants. Medium-level student courses will take two weeks while high-level student courses will last only one week. An overview is presented in Table 3.

Table 3: Presence learning group arrangement.

Group number	Student ability level	Maximum of students in one group	Duration of lessons
1	low level	10	3 weeks with 6 hours a day
2	medium level	20	2 weeks with 6 hours a day
3	high level	35	1 weeks with 6 hours a day

New students have to complete the courses weekly to prevent a separation in different learning groups corresponding to the ability levels. Students with low-level abilities are starting in small groups of 10 participants. After one week students with medium abilities join these groups up to a maximum of 25 participants. They are starting again with the same mathematical subjects, but quicker.

One week later, students with high-level abilities complete the courses up to 35 participants and the whole course starts again with the same subjects but even quicker.

The advantage of this is that the students with lower abilities had the possibility of repeating the same subjects several times. The learning velocity of students with higher abilities is adequately taken into account. We prevent a separation of students due to their different skills in the beginning because all students should recognise an equalized state of knowledge of the other participants in their course.

The online-learning course starts prior to the presence courses and it can be attended additionally. The course is adapted for every student. The results of the mathematical test are taken into account for a dynamic generation of personal feedback and for giving learning advice. The feedback is given with textual and graphic analysis, symbolic and textual learning advice. Due to the motivational design by John Keller, screencasts are used to get attention and simple mathematical tests with optical feedback are used to keep attention, to show the learning enhancement and to support confidence and satisfaction. Like in serious games the personal aim is to get as much positive optical feedback as possible.

The adapted blended learning design as shown above is summative and formative evaluated. Due to this the learning outcome proven and structured feedback is available to optimise the whole coaching process.

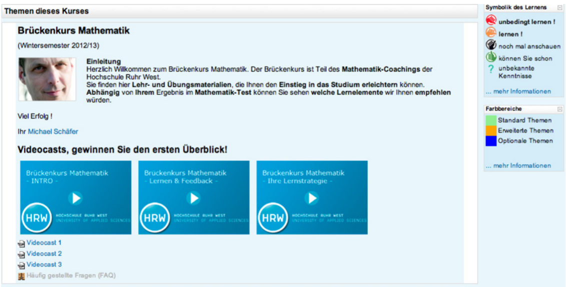
4 IMPLEMENTATION

The mathematical coaching was developed in the year 2010 and it was used with 335 students in the year 2011. After a formative evaluation with the result of an overall good feedback but a less good acceptance of the online learning course (Schäfer et al., 2012), the motivational elements were enhanced. In the year 2012, more than 600 students took part.

The mathematical test of each student was done as paper and pencil test. Here, an anonymous number and the email-address were collected to be able to send necessary information about the organisation of the presence and online courses. The results were stored in an SQL-database being part of the learning management system (LMS). Moodle (Moodle Development Team, 2012) was used as LMS.

Twenty teachers in three locations have done the presence courses after a professor of the university instructed them. Clustering students through competence and study path did the matching. A homogenies cluster with a teacher of the same background/similar degree was built.

An individual mail with the account data to the LMS, the time and place of the best matching mathematical courses was generated and distributed. The online mathematical course combines an all-embracing amount of learning material with a pedagogical and motivational concept to improve the usage of this material and the learning outcome. The LMS-design is based on the university corporate design and enhanced with many graphical and interactive elements. The front page is shown in Figure 1.



Themen dieses Kurses

Brückenkurs Mathematik

(Wintersemester 2012/13)

Einleitung
Herzlich Willkommen zum Brückenkurs Mathematik. Der Brückenkurs ist Teil des **Mathematik-Coachings** der Hochschule Ruhr West.
Sie finden hier **Lehr- und Übungsmaterialien**, die Ihnen den **Einstieg in das Studium erleichtern** können.
Abhängig von **Ihrem** Ergebnis im **Mathematik-Test** können Sie sehen **welche Lernelemente** wir Ihnen **empfehlen** würden.

Viel Erfolg !

Ihr Michael Schäfer

Videocasts, gewinnen Sie den ersten Überblick!

Figure 1: Front page of the mathematical online course.

It gains attention by personally addressing the student and by using motivating screencasts (Figure 2), which reflects the important of mathematical knowledge and guides the students through the next steps.

Figure 2: Screen casts as motivational elements.

They are invited to look at their personal test score as starting point for their own self-regulated learning concept.

As shown in Figure 3 the students can see their own score, the average score of all students and the expected score the university teachers have. For simplicity reasons, the scores are clustered by topics equal to Table 2.

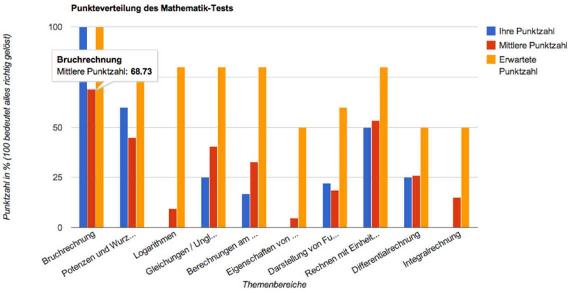
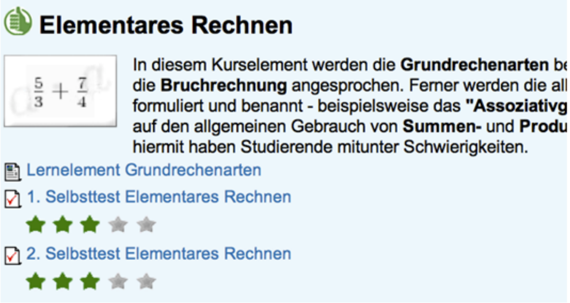


Figure 3: Personal math test result (Blue (first column) – own score of the student (depending on Moodle user), Red (second column) – average score of all students, Orange (third column) – expected score by teachers).

Having had a look at this first feedback, the students are invited to watch the second screencast about learning and feedback (Figure 2). Here they are informed about the feedback symbolism like for example the thumbs to reflect the results of the mathematical test in the current subject. Like the good knowledge of the student with the green thumb up at the top of Figure 4. After reading these explanations the students are guided to pass the first learning element and to do the first mathematical self-test.

A graphical rating scale gives them feedback on their success and the students can prove this by doing a second similar test.

An example is shown in Figure 4.



Elementares Rechnen

In diesem Kurselement werden die **Grundrechenarten** b
die **Bruchrechnung** angesprochen. Ferner werden die all
formuliert und benannt - beispielsweise das **"Assoziativg**
auf den allgemeinen Gebrauch von **Summen-** und **Produ**
hiermit haben Studierende mitunter Schwierigkeiten.

Lernelement Grundrechenarten

1. Selbsttest Elementares Rechnen

★★★☆☆

2. Selbsttest Elementares Rechnen

★★★☆☆

Figure 4: Feedback elements in the online course.

To enhance the engagement and the average length of course-usage an avatar is embedded. This virtual coach, implemented as 3D humanoid character, is used to give feedback and learning advice. Different implementations were evaluated. On the one hand, a lean design of the automotive sector as shown in Figure 5 with text-to-speech translation, which could easily be used for dynamic interactions (CharAt, Version 1.0) was tested. On the other hand, pre-recorded but realistic 3D animated humanoids with synchronized audio from voice-over artists were tried.

Figure 5: Alex as virtual coach in the online course.

This was topped off with short mathematical tests at the end of each week in the presence course and a mathematical test at the end of the coaching process, which is equivalent to the mathematical test done before the coaching was started.

5 EVALUATION AND RESULTS

Three different data sources are used for evaluation. Firstly, it was the log-data of the LMS to prove the usage of the online mathematical course.

Secondly, the summative evaluation of learning outcome based on the mathematical tests before and after the coaching was used.

Thirdly, the formative evaluation one month after the end of the coaching to evaluate the whole system was taken into account.

5.1 Log Data

An anonymous ID and an email address were collected with the mathematical test done in the beginning. Due to data privacy policies it was not allowed to use the data from matriculation. With this data, 613 individual mails with the accounts to the online course were generated. 32 mails came back with failure notices. About 50 mails were suspended to the spam-folders of the recipients by one email-provider. We suppose that a significant part was not read, because of the communication shifts from email to other channels like social media platforms.

In the online course 493 students watched their personal result as shown in Figure 3. The first videocast was watched by 191 students (1200 page views), the first learning element (elementary calculation) was used by 286 students, the second from 282 (powers and radicals) students, the fifth (function) was only used by 149 students. The usage of selftests have the same tendency from 155 students using the first selftest to 24 students using the eleventh selftest.

5.2 Summative Evaluation

In the beginning n=613 of all new students took part in the voluntary mathematical test. This is only a part of all new students (N=893), because the matriculation was possible until the first day of studies. The information about the mathematical coaching and the account to the online course were sent to the students one month prior to the start of studies and the presence course started three weeks before the studies began.

5.2.1 Results before Coaching

Out of 48 items an average value of AVG=13.70 items were correctly solved with a standard deviation of SD=8.82.

5.2.2 Results after Coaching

After our coaching the students could pass another mathematical test with 48 equivalent items (n=132). The results are based on a paired-samples t-test.

The average value of correctly solved items was AVG=28.48 with a standard deviation of SD=7.31. Depending on the kind of eligibility of university admission, the following differences between the different groups are to be found:

a) General eligibility with advanced mathematic course
n=41, AVG=31.90, SD=8.71

b) General eligibility with basic mathematic course
n=37, AVG=28.51, SD=8.07
c) Subject-linked eligibility
n=50, AVG=26.20, SD=8.69

5.3 Formative Evaluation

A formative assessment is done one month after the studies start to evaluate the usability, acceptance and performance of the coaching-system. The survey consists of 27 items with 12 different dimensions. The first evaluation in 2011 was only done with a small part of the participating students (N=49). First of all we were not sure, if a mathematical test, before the studies are starting, will be accepted. With an average value of AVG=5.42, a standard deviation of SD=.93 and a median of SM=6 the students seem to accept the test as reasonable. Visiting the presence learning courses was profitable for the students with an average value of AVG=5.84, a standard deviation of SD=1.25 and a median of SM=6. In a 5-level-Likert scale (Likert, 1932) the students estimate the influence of the small group-sizes with an average of AVG=1.7 and a standard deviation of SD=1.37 (1: very positive, 2: positive...).

For the question, if using the e-learning platform was profitable to them, the students estimated with an average of AVG=3.74, a standard deviation of SD=1.39 and a median of SM=4. So only a slightly positive result was measurable. Whereas the visiting of the presence-learning course in combination with using the e-learning platform was profitable for the students with an average of AVG=4.93, a standard deviation of SD=1.47 and a median of SM=5.

The overall feedback for fitting the demands of each student, self-observed learning effects and helpfulness for the first year courses was positive. We used these results to improve our online-system as shown before.

6 CONCLUSIONS AND FURTHER WORK

The knowledge controlled mathematic coaching concept was successfully implemented. The summative evaluation shows a significant increase of the mathematical competences of new students prior to the beginning of their studies.

We plan to use our results to further enhance the concept to improve the mathematical competence of the students and the technical implementation. The adaption of e-learning material, the personalized feedback and the arrangement of learning groups depending on the students' competence have positive effects on the improvement of current math skills of first year students. The enhancement through avatars seems to be promising.

In conclusion, this paper presented the implementation of a learner centred adaptable blended learning concept. The mathematical coaching significantly improves learning effects. These effects are controlled by summative and formative evaluations. Some efforts of future work are still necessary in order to enhance this concept and optimise its implementation.

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The Course “English for Biologists” and Web Page ‘APres’

How Modern Communication Technologies Help to Promote Communicative Competence

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Keywords: Communicative Competence, Communication Technologies, Academic Presentation, Independent Learning, Specific Language Skills.

Abstract: The paper deals with the course “*English for biologists*”, which has been designed and developed for the students of the Department of Natural Sciences of Novosibirsk State University. The main aim of the course is to form specific language skills: academic listening and giving oral academic presentations. The course is described in some detail. During the four stages of the course each student has to give four academic presentations. The paper considers some of the ways the students use computers and the Internet in acquiring the course. The skills are studied that are formed with the help of modern communication technologies. To help the students cope with the course the Web page *APres* has been created. It provides useful information and advice for the students and for all those people who want to learn how to give and comprehend oral academic presentations. The Web page *APres* is briefly outlined.

1 INTRODUCTION

Biologists study English at the Department of Natural Sciences (DNS) of Novosibirsk State University (NSU). In the course of English, they are to acquire enough knowledge and skills for the practical use of the language. They are supposed to learn how to: 1) read and comprehend texts on their speciality; 2) write reports and papers; 3) give and comprehend oral academic presentations.

The course “*English for biologists*” has been designed and developed in addition to the general course of English. It allows to form specific skills in *ESP* (*English for Specific Purposes*). Some of them are academic listening (listening to lectures and other academic presentations) and giving oral academic presentations (lectures, reports). The course consists of four stages and lasts four semesters. During the course, every student gives four academic presentations. To prepare for them students use the texts read during the semester.

The Internet is widely used in the course: the electronic dictionaries are used to read and translate texts; the search engines – to find some extra information on the topics of their presentations. Word processors are employed to prepare the written texts of presentations.

The activity of preparing and delivering presentations is a real challenge for non-language students. In order to help them cope with the problem a resource Web page has been created – the Web page *APres* (*A*cademic *Pres*entations). It is aimed to equip students with the necessary language skills and communication techniques.

2 SPECIAL COURSE “ENGLISH FOR BIOLOGISTS”

Biologists are trained in their speciality at the research institutes of the Siberian Branch of the Russian Academy of Sciences. The professional training is guided by scientists who tackle major scientific and engineering problems.

Students participate in practical and scientific seminars, workshops, and conferences as well as in writing reviews, reports, and collective papers. Many scientists co-operate and communicate with their foreign colleagues in English. Taking part in real research work the students understand that they have to learn how to communicate in English.

The course “*English for biologists*” is an *ESP* course. The main objective of any *ESP* course is to help students acquire the linguistic and communicative skills related to their disciplines, so a content-based approach is especially useful. Content-based instruction "employs authentic reading materials which require students not only to understand information but interpret and evaluate it as well ..." (Brinton et al., 1989).

The Internet is a learning tool that fits well in a content-based *ESP* syllabus. There are some important benefits of the Internet use: 1) more opportunities to interact with the target language and content area because students spend more time on a task; 2) increased motivation and participation by the students; 3) greater integration of reading and writing skills and opportunities to practice them in meaningful contexts; 4) more self-paced autonomous learning that is learner-controlled rather than teacher-controlled.

The students who study English at the DNS NSU are mostly low-intermediate students. Being adult learners they face difficulties in mastering speaking and listening skills. The fact is that adult learners can speak about very serious matters and issues in their native tongue but have very limited means to express their thoughts and ideas in English. When teaching we have to take into account both the language level of the students and their command of speciality (Hutchinson and Waters, 1992).

The course "*English for biologists*" is primarily intended to form the skills of academic listening and giving oral academic presentations.

The students are taught to communicate. The Internet is utilized in this process as a research tool, a conversational tool, and a production tool. Various language skills can be practised and acquired with the help of the Internet.

2.1 Oral Academic Presentations at the 1st and 2nd Stages of the Course

The work pattern at the 1st and 2nd stages of the course is the same. Every student chooses a text from the book suggested for the presentations and once a semester gives a presentation. Then there is a discussion. Speaking and listening skills interrelate and interact very closely here. Reading and writing are also involved.

For the 1st series of presentations the book *Right Reading* (Beginning Level) by Dean Curry is taken. The texts are short (450-600 signs), easy to read and understand and related to biology. They outline such topics as the wildlife, the survival of species in the process of natural selection, etc. There are five or six exercises in each chapter and a glossary.

At the 2nd stage of the course we take the book *Read On* (Intermediate Level) by Dean Curry for academic presentations. The texts tell us about such problems as recognition of smells by animals and people, radar system in bats, etc. The texts and exercises are more complicated, but short and related to biology as well.

The techniques of preparing and delivering presentations are thoroughly elaborated. The manuals for speakers have been developed. They are: *'Listening Strategies'*, '*Speaking Strategies'* and '*Manual for speakers. Academic Presentations. 1st and 2nd Stages'*.

2.2 Scientific Conferences at the 3rd and 4th Stages of the Course

The work pattern changes at the 3rd and 4th stages of the course. The activity results in two scientific conferences: "*Disease. The Greatest Agent of Natural Selection*" and "*Bacteria. The Workhorses of Biotechnology*".

The 1st conference is held at the end of the third semester. To prepare for the conference the students use texts from the book *"Clones, Viruses, etc. Reading and Speaking on Biology and Medicine"* (Snytnikova, 2002; 2006) read in the semester. The texts are rather long (1,000-1,500 signs) and related to biology. They are dedicated to such academic topics as the causes of diseases, the nature of viruses, etc. The texts are read aloud, translated, and thoroughly analyzed in class. All the exercises that accompany the texts are fulfilled. All the four language skills are acquired here. Subject-specific lexical items are accumulated.

A number of conversational gambits are studied, which can be useful in the course of an academic presentation. The students get to know when and how to take the floor, how to introduce a topic or change the subject, etc. (Nunan, 1992).

2.2.1 3rd Stage. Conference "*Disease. the Greatest Agent of Natural Selection*"

Every student chooses a text that he will use to prepare an academic presentation for the conference. Students write the texts of presentations making use of the key points from the text and special conversational gambits.

They employ their skills in *Multi-Skills Reading* in the process. The following reading skills are involved: 1) skimming for key words; 2) scanning for specific information; 3) reading in meaningful units; 4) recognition of clues, which signal phrases.

The students use the writing skills they have acquired and organize the content at the level of the paragraph reflecting the given information.

Finally, students give oral presentations at the conference "*Disease. The Greatest Agent of Natural Selection*". The topics are "Disease", "Virus", "Cancer", etc. Some new speaking skills are involved here: 1) using appropriate conversational formulae and filters; 2) skills in taking short and long speaking turns. New *Oral Communication Skills* for *Academic Purposes* are formed: 1) an acceptable degree of fluency, and 2) transactional and interpersonal skills. All students prepare one or two questions on the topic of each report. They are asked in the discussion after the reporter has given his presentation.

2.2.2 4th Stage. Conference "*Bacteria. the Workhorses of Biotechnology*"

The conference "*Bacteria. The Workhorses of Biotechnology*" is the ultimate aim of the course. It is held at the end of the 4th semester. The material is the article from *National Geographic* named *Bacteria. Teaching Old Bugs New Tricks* (Candy, 1993). The article is big – 30,000 signs. It is studied thoroughly during the semester both in class and at home: it is read aloud, translated, and discussed.

Then the students are offered a list of presentation topics. The themes relate to various modern biotechnologies using bacteria. For example: *1) Microbes as factories making pharmaceuticals, pesticides, solvents, and plastics; 2) Using bacteria for bioremediation,* etc.

To prepare for the presentation every student has to look through the whole article again, find all the information concerning the given topic, analyze it, decide, which part of it to include into the report. After that he writes his report and presents it at the conference. While presenting he is to use *Conference Lexicon* properly.

Everyone also makes up a list of questions on all topics in advance. After the presentation there is always a question-answer session and a discussion. The whole group takes part in it.

2.3 How the Internet and Computers Are used in the Course "*English for Biologists*"

In their work with the course *"English for biologists"* students widely use computers and the Internet.

While reading and translating the texts they make use of electronic dictionaries but not the paper ones. It is faster, more comfortable, and cheaper. You can also find transcriptions of any words on any speciality in on-line dictionaries whereas English-Russian special paper dictionaries do not give transcriptions. Many on-line dictionaries provide not only quick search, but also high quality sound. So one can read the word, hear it, and pronounce it properly after the computer.

When preparing for the conferences at the 3rd and 4th stages of the course my students and I regularly exchange e-mail letters. The students send me rough copies of their conference reports. Having checked and corrected them I send them back. It allows me to carry out individual distance teaching providing my students by a feedback channel.

One of the students is chosen to be the secretary of the Conference. He is responsible for the printed materials. All students send him e-mails with the titles of their reports and some other necessary information like their names and surnames in English spelling, etc. He, then, makes up the conference program and prints it out.

We publish conference proceedings. Reports to be included into the proceedings are often e-mailed too. The students write all this outside class. Thus, they always have some extra practice in English.

Some of the skills acquired with the help of the Internet and other modern communication technologies are: reading (reading for detail, reviewing and predicting); writing (copying parts of information, expressing opinions); speaking (talking about current scientific news), etc.

The information in the Internet is obtained immediately, which provides strong motivation for careful reading. You can even write a letter to the author of the article or the editor of the journal (Teeler, 2000).

Students use a word processor to prepare the texts of the presentations in written form. It helps them develop writing and editing skills.

3 WEB PAGE 'APres'

Modern communication technologies greatly extend language-learning opportunities. The Internet is suitable for any language course designed around the specific needs of a particular group of students.

The Web page *APres* (**A**cademic **Pres**entations) is aimed to provide useful information and advice for students who take the course *"English for biologists"* and for everyone who wants to learn how to prepare and deliver an academic presentation. It equips students with the necessary language skills and communicative techniques.

APres consists of eight sections: 1) General information; 2) Conference lexicon; 3) Presentation techniques; 4) Conferences; 5) Photos; 6) Poster guidelines; 7) Notes for writers; 8) Feedback. Section 2 contains the necessary conversational gambits. Section 3 is dedicated to the ways of preparing and delivering academic presentations. Section 6 teaches how to make a good poster. Other sections are equally relevant. All the sections are linked together.

The Web page *APres* is most purposeful and effective as it is learner-centred, based on authentic communication and connected to a larger goal – developing academic skills. It is a multimedia resource and communication tool, which both supports class-based learning and helps to develop independent learning skills in students and improve their language competence.

4 CONCLUSIONS

The course *"English for biologists"* is an *ESP* (English for Specific Purposes*)* course. The aims of the course are to help students to form linguistic and communicative skills related to their discipline. The course is based on the content of the subject and on the use of authentic materials. The students' linguistic needs and learning styles are considered carefully.

Every student gives four academic presentations during the course. Presentations are popular with the students. All the four language skills (listening, speaking, reading, and writing) interrelate and interact very closely here. The students also acquire communicative competence. They learn to be effective while communicating on professional topics.

The given course can easily be transformed into a course for ecologists, chemists, etc., if you change the content, as the course is content-based.

The technologies of computer-aided learning, such as the Internet and e-mail, help the students greatly in acquiring necessary linguistic and communication skills here.

The Web page *APres* has been created as a supplement to the course. This Web page is a kind of blended learning environment, in which modern technologies both support class-based learning and help to develop independent learning skills in students. It also helps to promote their communicative and language competence.

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How to Equip Students with Methodologies and Tools for Capturing Rapidly Changing Environments through Computer Supported Education

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Keywords: Matured Market Economy, Customer Segmentation, The 70-30 Principle, Intermediary DB, Profile Vectors.

Abstract: In the midst of the global mega-competition, the most competitive battle fields of economy, often referred to as the tripod consisting of the United States, EU and Japan, has entered the matured market economy where consumers are interested in acquiring goods and services to fit their particular needs, demanding a variety of products and services in small quantities. Accordingly, corporations now have to deal with segmented submarkets which change quite rapidly. For achieving the leading competitiveness in this new environment, it is no longer sufficient to capture the entire market as a whole. Instead, it is necessary to trace and analyze the segmented submarkets separately. In order to overcome this difficulty, methodologies and tools are needed for extracting effective managerial implications from the massive data collected through the Internet with speed and accuracy. The purpose of this paper is to demonstrate how to equip students with such methodologies and tools through computer supported education.

1 INTRODUCTION

The growing market economy may be characterized by the fact that consumers share the sense of lacking goods and services for consumption and are eager to possess what others have. In contrast, in the matured market economy, consumers tend to pursue individual tastes in consumption so as to maximize their own sense of satisfaction. In other words, consumers are interested in acquiring goods and services that others may not have but fit their particular needs. Naturally, this trend results in a variety of products and services in small quantities and the market segmentation becomes extremely important. A typical successful R&D strategy in this stage would be the market-in strategy, where a variety of products are introduced into the market in small quantities in response to particular needs in particular market segments. Such products in the matured market economy would have much shorter life cycles than those in the growing market economy, causing rapid changes in the segmented submarkets.

As long as the real economy is concerned, the economies of scale is always present. Since the matured market economy requires more detailed marketing strategies for individual segmented submarkets, the efficiency resulting from the economies of scale tends to diminish. In other words, if corporations have to deal with separate segmented submarkets in a one-on-one manner, the profit margins would inevitably decrease. In order to overcome this difficulty, methodologies and tools are needed for extracting effective managerial implications from the massive data collected through the Internet.

The central approach for achieving this goal would be to apply the 70-30 principle, proposed by the authors in (Sumita and Yoshii, 2012), to the information processing procedures, where such procedures for separate segmented submarkets are designed 70% in common with remaining 30% for customization so as to cater for peculiarities of individual submarkets. This observation would be valid across many different industrial sectors. Accordingly, from a pedagogical point of view, it is very important to familierize students with the 70-30 principle applied to information processing, no matter what industrial segment they plan to enter after graduation.

The purpose of this paper is to demonstrate how to equip students with methodologies and tools for implementing the 70-30 principle in information processing through computer supported education. In this paper, we focus on dynamic customer segmentation in e-marketing for enhancing CRM (Customer Relationship Management). A pedagogical training scheme is illustrated explicitly through computer supported education. Furthermore, we clearly outline the procedures for extracting managerial implications from the massive data collected through the Internet.

2 DYNAMIC CUSTOMER SEGMENTATION IN E-MARKETING FOR ENHANCING CRM

More than a decade has passed since the Internet gained its significant presence in the world. It has penetrated into many aspects of business practices and has been drastically changing the traditional business models in almost every industry. In the retail chain business, for example, it is now possible to collect and accumulate massive data from the market via a POS (Point of Sales) system and utilize them so as to develop effective marketing strategies for enhancing sales of products. An extensive literature exists for analyzing consumer purchasing behaviors based on POS data, represented by (Taguchi, 2010; Eugene, 1997; Ishigaki et al., 2011; Yada et al., 2006) to name only a few.

The problem we face here is the excessive computational burden, where the tremendous amount of POS data collected from the market has to be analyzed repeatedly in a timely manner. In order to overcome this difficulty, we introduce the concept of profile vectors as an intermediary information base between various analytical engines and the DB of POS data.

Figure 1 depicts the basic framework for implementing dynamic customer segmentation. Here, a variety of profile vectors, such as CPV (Customer Profile Vector), PPV (Product Profile Vector) and SPV (Store Profile Vector), are automatically constructed and updated periodically from the DB.
These profile vectors are then used by different analytical engines, producing the standard reports

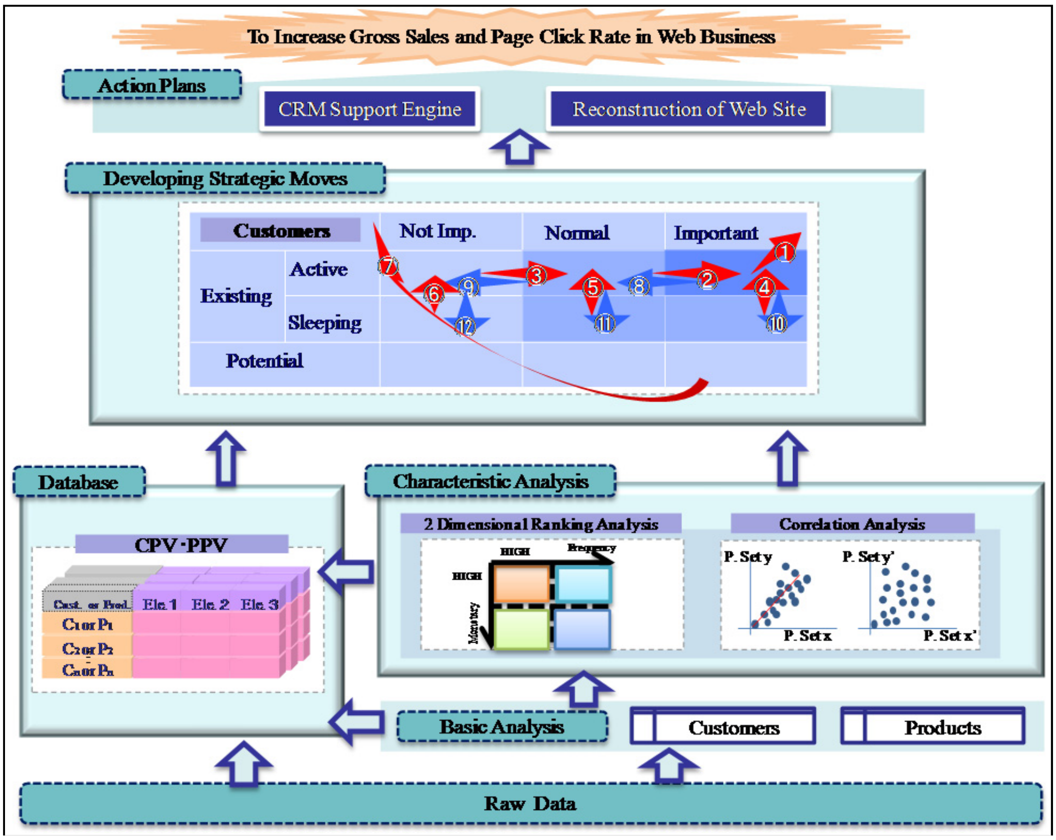

Figure 1: Dynamic customer segmentation for enhancing CRM.

from the basic analysis as well as some ad hock reports derived from characteristic analyses specified by a manager through the graphic interface. Furthermore, these results are used to update customer segments dynamically so as to yield different marketing strategies applied to different customer segments.

CRM typically means that the lifetime value of a customer is to be maximized by maintaining two way communications between the customer and the company through the Internet. This concept is limited in that the potential customers are not addressed explicitly. By combining POS data with transaction data on the Internet, not necessarily linked to purchasing, it is now possible to capture the entire market as depicted in Figure 1, where the market is decomposed into 9 segments: (Existing-Active, Existing-Sleeping, Potential) × (Not Important, Normal, Important). The arrows (1) through (7) indicate the desirable changes of the market for the company, whereas the arrows (8) through (12) represent the changes of the market to be avoided. The new marketing approach for enhancing CRM would then be to devise strategic moves so as to promote the moves along favorable arrows and prevent the moves along unfavorable arrows. Since such customer segments have to be updated dynamically, the profile vector approach becomes crucial for containing the underlying computational burden. This example demonstrates the importance of the 70-30 principle in e-Marketing.

For establishing a base for computer supported education through this example, where students can learn how to develop and maintain the dynamic customer segmentation system illustrated in Figure 1 based on the 70-30 principle, a computer simulator for the dynamic customer segmentation system is installed in a server at Sumita Research Laboratory in parallel with the system developed at the collaborating e-business company through the joint research project. Real data collected from the Internet are fed into the simulator once a week. This simulator enables students to actively get involved in the decision process for development and analysis of e-marketing strategies.

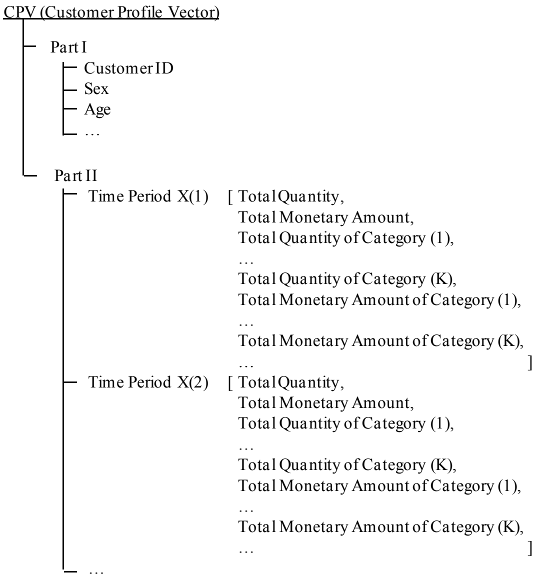

Figure 2: Customer profile vector.

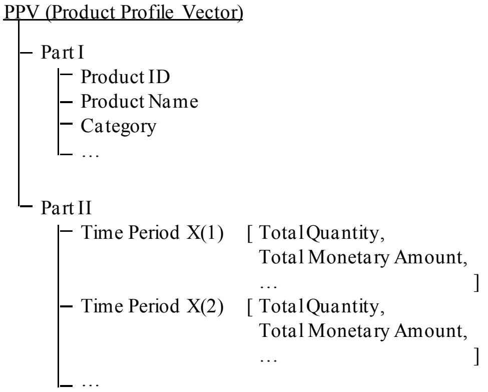

Figure 3: Product profile vector.

3 CONCLUSIONS

In the matured market economy, consumers are interested in acquiring goods and services that others may not have but fit their particular needs so as to maximize their own sense of satisfaction. Naturally, this trend results in a variety of products and services in small quantities and the market segmentation becomes extremely important. Such products introduced in response to segmented submarkets would have much shorter life cycles, causing rapid changes in the segmented submarkets. In this paper, we propose a general scheme involving methodologies and tools for capturing such rapidly changing environments.

The proposed general scheme is based on the 70-30 principle, proposed by the authors in (Sumita and Yoshii, 2012), applied to the information processing procedures, where such procedures for separate segmented submarkets are designed 70% in common with remaining 30% for customization so as to cater for peculiarities of individual submarkets. The key success factor for development of the general scheme is to introduce profile vectors as an intermediary DB, where the majority of necessary information for running analytical engines can be extracted from such profile vectors without going back to the DB, achieving the necessary speed.

In order to describe the general scheme clearly, one concrete application area is discussed: dynamic customer segmentation in e-marketing for enhancing CRM (Customer Relationship Management). A pedagogical training scheme is illustrated explicitly through computer supported education. Furthermore, we clearly outline the procedures for extracting managerial implications from the massive data collected through the Internet. It is expected that the 70-30 principle applied to massive information processing for capturing rapidly changing environments provides a general guidance to enhance the strategic flexibility and the business agility in other areas to be competitive in the midst of the global mega-competition in the 21st century.

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Using Non-graded Formative Online Exercises to Increase the Students' Motivation and Performance in Classroom

A Longitudinal Study from an Undergraduate Information Systems Program in Singapore

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Keywords: Online Assessment Tools, Non-graded Formative Assessments, Increase Students' Motivation and Performance.

Abstract: In a seven terms (i.e., three and a half years) longitudinal study the author has examined how the use (respectively non-use) of interactive non-graded and formative online exercises has impacted the students' attention and motivation in the classroom and, consequently, their level of performance in graded course assessments. This practice paper describes an interactive online system for non-graded assessments which was conceptualised, designed and implemented at the School of Information Systems, Singapore Management University, and this paper presents an analysis of students' performance data gathered in a large compulsory senior-level course, particularly focusing on the comparison of the system users' performance with the system non-users' performance in selected graded assessment components.

1 INTRODUCTION

This paper reports on the results of a three and a half years longitudinal study in which the author of the paper has examined how the use (respectively non-use) of non-graded formative online assessment exercises has impacted students' motivation and performance level in class.

The paper unfolds the following manner.

In chapter two of this paper, the author undertakes a brief review of the role of formative non-graded assessments in higher education. This review shows that – contrary to graded assessments – the question on how non-graded assessments can be used to enhance students' performance in class has been rarely discussed in the higher education literature.

Chapter three discusses the use of online assessment tools, systems and applications in higher education and examines the role of information technology in the space of higher education assessments.

In chapter four, the web-based system for non-graded formative classroom exercises (FACE) designed and implemented at the School of Information Systems, Singapore Management University, is introduced. The chapter briefly introduces the most important features of FACE and also briefly describes a specific application example of the FACE system.

Chapter five presents a brief analysis of the data which was collected over the period of three and a half years. This chapter not only examines the performance data in FACE exercises, but also conducts an analysis of the correlations between the use of the FACE application and the students' performance in selected graded assessment components in the course.

Chapter six concludes with a brief reflection on the usefulness and effectiveness of formative non-graded online exercises in undergraduate programs and makes suggestions on how such exercises could be used to enhance students' motivation, captivate students' attention, and, consequently, to raise students' performance level in class.

2 THE ROLE OF FORMATIVE NON-GRADED ASSESSMENTS IN HIGHER EDUCATION

While there is an abundance of research concerned with the role of graded assessments and exercises in higher education (Black and Wiliam, 1998); (Cowan, 2002); (Nicol et al., 2005); (Rust et al., 2003); (Taras, 2002); (Zvacek, 1999), only little attention has been devoted to the role of non-graded assessments (Anthony and Raymond, 2004). Moreover, it seems that there is no clear understanding on how summative, formative and self-assessments relate to each other (Taras, 2008b).

Some of the research investigating the effectiveness of non-graded assessments claims that there is a lack of logic in the argument that working in a non-graded context is the best way for students to build up knowledge for formal, graded assessment (Duvall, 1994); (Taras, 2005); (Warren, 1998). Consequently, the non-graded exercises are unlikely to receive the same attention from the students as the graded assessments (Taras, 2008a). Thus, some research argues that – if understanding the graded assessment component is the ultimate goal – then it would be more effective if these were the point of focus and not the non-graded exercises (Anthony and Raymond, 2004).

Selected research, however, shows that all too frequent graded assessments have a “negative impact on motivation for learning that militates against preparation for lifelong learning” (Harlen and Crick, 2003) – this way arguing that non-graded assessment exercises would actually help to achieve the opposite effect.

Some research work seems also to suggest that graded assessments force students to focus on performance rather than learning (Grant and Dweck, 2003). This would, in turn, imply that non-graded assessments support students in focusing on the subject mastery and on the learning process instead of thinking of “passing the course”.

3 ONLINE ASSESSMENT TOOLS IN HIGHER EDUCATION

The use of web-based interactive learning and teaching tools has increased tremendously over the past decade. There are numerous commercial and open-source learning and teaching management applications currently available on the market (Blackboard, Desire2Learn, WebCT, Moodle and others).

Recent research has shown that online-based teaching and learning tools may improve students’ learning and performance in higher education courses. Selected research has examined the use of interactive, computer-based assessment tools for the purposes of student practice and feedback and found a significant performance difference between students using the computerised practice tests and those who did not (Gretes and Green, 2000). The use of computer-based assessment and practice tools also seems to have a positive impact on students’ motivation (Thelwell, 2000).

In addition, research has found that online-based or computer-based teaching and assessment tools are also attractive to the teaching personnel as they increase interactivity in the classroom and make assessments and activities more attractive to students (Wolsey, 2008).

Most recently, the term eAssessment has been adopted in the higher education research. Pachler (Pachler et al., 2010) employs the term *formative e-assessment* which he has defined as “the use of ICT to support the iterative process of gathering and analyzing information about student learning by teachers as well as learners and of evaluating it in relation to prior achievement and attainment of intended, as well as unintended learning outcomes” (p. 716). This definition stresses the important role of information technology in the space of higher education assessments and can be applied to graded and non-graded assessments equally.

4 INTRODUCTION TO “FACE”

4.1 The Origins of FACE

The web-based system for non-graded formative classroom exercises (FACE) was fully designed and implemented at the School of Information Systems, Singapore Management University.

When evaluating open-source as well as licensed products currently available on the market, the author of the paper specifically focused on the following requirements:

1) Ability to integrate with university-internal course, curriculum and personnel management systems
2) Ability to facilitate individual use of the system across different groups (i.e., sections) of one and the same course

3) Ability to work with flexible and configurable exercise templates
4) Ability to collect and use student performance data and to monitor students' performance during the course
5) Ability to publish and un-publish exercises for particular weeks

As none of the evaluated systems fully satisfied the requirements, the author has decided for an in-house implementation of the system.

4.2 Functionalities of FACE

The FACE application is a web-based system which has been designed using Microsoft ASP.NET and Microsoft SQL Server technologies. The FACE application uses Windows credentials and Enterprise Single-Sign-On to authenticate the users. Moreover, the FACE application is tightly integrated with a university-internal course management system.

The FACE application has two main interfaces: one interface is exposed to students (i.e., the practicing interface) and one interface is exposed to the teaching personnel (i.e., the administrative interface).

The administrative interface provides the teaching personnel with the following major functionalities:

1) Setting up formative non-graded exercises for a given session based on a range of pre-defined exercise templates
2) Determining the desired number of exercises per session
3) Manually opening and closing the exercises or setting a specific date and time range when the exercise can be accessed
4) Configuring the correct solutions for a given exercise
5) Determining the number of attempts after which the students will be able to access the correct solutions for the given exercise
6) Examining the results of the exercises using graphical data analysis tools

The practicing interface exposes to the students the following major features:

1) Accessing the formative non-graded exercises opened for a given session and executing those exercises
2) Accessing the correct solution for a given exercise after the pre-set number of attempts
3) Monitoring the own performance across several sessions

The exercises in FACE are non-graded, they are formative in nature and there is no specific time limit enforced to complete a certain exercise. Upon saving the selected set of responses, the system notifies the student if the exercise has been solved correctly. Once a certain number of attempts for a given exercise has been reached, the students can (if they chose to do so) access the correct solution for that exercise. Otherwise, the students may re-attempt the exercise until they achieve the correct solution themselves without consulting the solution repository.

4.3 Use of FACE in the Enterprise Web Solutions Course

4.3.1 The Enterprise Web Solutions Course

The Enterprise Web Solutions course is a large compulsory third year course at the School of Information Systems, Singapore Management University. This course focuses on the enterprise portal technologies and it exposes the students to the complete life cycle of an enterprise portal in an organisation.

The course is run both academic terms – in term 1 (August to December) and in term 2 (January to May). In term 1, 160 students in total are taking this compulsory course, in term 2, 80 students are taking this course. Out of the 160 students in the first term, 80 students have been constantly using the FACE application, out of 80 students in the second term, all 80 students have been using the system.

4.3.2 Deployment and Productive use of the System

The initial deployment of FACE took place in January 2010.

To enable long-term comparison, the exercises set up for the Enterprise Web Solutions course were similar across all sections of one particular term, and the exercises were similar across different terms, too. To achieve this similarity, consistently the same exercise templates were employed, and similar and comparable content was used to "feed" the exercise templates.

All formative assessment exercises set up in the FACE application were targeted at students' self-reflection and self-testing. Most importantly, the exercises did not require the students to memorise facts, to copy answers from the given lecture material, or to guess the correct answers.

Rather than that, the exercises encouraged the students to seek for the underlying meanings, to explore relationships between different concepts, or to compare advantages and disadvantages of specific approaches. In addition to that, one of the most essential intrinsic values of those exercises was their non-graded nature.

This means, that the students were able to complete those exercises without any fears of earning a bad mark or negatively impacting their score for the course.

5 DATA ANALYSIS

5.1 Data Collection

The FACE system collects diverse quantitative data on students' performance in the exercises.

Firstly, the system captures the number of attempts which a particular student needs to complete a given exercise. Secondly, for a given attempt of a particular exercise, the system captures the "correctness" or "incorrectness" not only for the exercise as a whole but also for every individual response within a given exercise. Thirdly, the system captures the time elapsed between a particular student's attempts of the same exercise.

This quantitative data captured within the system is used in several ways.

During the course, the teaching personnel can use charts and other visualisation means produced by the application, to display to students the overall class performance in terms of attempts needed to complete the exercise. The system also uses this data to provide the students with an immediate feedback concerning the correctness of their individual solution. In addition to that, the system allows the students to monitor their own performance across several sections of the course – e.g., monitoring how many attempts they need to solve a given exercise, how this number has changed over time. Moreover, the data is used by the teaching personnel to capture the most frequently made mistakes in a given exercise – and those problematic cases are usually selected as topics when carrying out the FACE exercise review at the beginning of each subsequent class.

In order to enrich the insights delivered through the quantitative data, the author of the paper has also conducted three informal student focus groups on the use of the FACE application. The first focus group was conducted one month after the introduction of the tool in the course. This focus group was primarily concerned with discussing with students their perceptions as to the use of the tool itself – the accessibility of the system, friendliness of use, any desired new features etc. The second focus group was conducted at the end of the first year of the system's use. This discussion particularly focused on the students' perception of the usefulness of this tool for their understanding of the course concepts. The third focus group was conducted at the end of the second year of the system's use and it was primarily concerned with understanding how the use of the FACE system is correlated with the students' performance in other course assessments.

5.2 Data Analysis

Although the data collected by the FACE application was used for different purposes, the most interesting findings were generated when analysing the correlation between the use (respectively non-use) of the FACE application and the students' performance in other assessment components of the course (the paper uses the data of one sample graded assessment of the course, namely, quizzes, and examines how the use (respectively non-use) of the FACE applications impacted students' performance in this particular assessment).

The performance data was analysed along three different dimensions: average time needed to complete the exercises, average number of attempts needed to complete the exercises, and average number of errors per attempt. Interestingly, while there is a clear positive change in students' performance within a particular term (e.g., the students need far more time to complete the exercise at the beginning of the term and considerably less at the end of the term), there are no changes in the performance across different terms – the pattern stays the same across all the examined terms.

The similar pattern across all examined academic terms is, however, easily explainable.

Due to the almost non-existent exposure of students to similar formative non-graded exercises in other courses, the students seemed to have considerable difficulties in developing the appropriate attitude to such exercises. Moreover, the students doubtlessly needed some time to develop adequate reasoning and evaluation skills – as the exercises primarily required the students "to look beyond the scenes" instead of memorising and reproducing some given facts.

The consistent pattern across all four terms under examination clearly suggests that non-graded formative exercises can considerably contribute to the development of such skills. With a comparably small time investment during the class (the Enterprise Web Solutions course devoted approximately 15 minutes to the completion of the exercises and additional 10 minutes to the discussion of the previous week's exercises), the students appeared to considerably improve in their abilities to quickly evaluate given concepts, assess the relationships among those concepts, to reflect on different aspects of those concepts (disadvantages vs. advantages, pros vs. cons), or to establish logical combinations of those concepts.

Further development of these abilities, in turn, seemed to have positive influence on the students' performance in other course assessments.

A comparison of the performance level in the quiz assessment for the students who used the FACE application versus the students who did not use the FACE application (considering the time period of the entire study reported in this paper – from term 1, 2009 to term 1, 20012) support this assumption.

The quiz assessment is conducted three times per term. The first quiz is conducted in week 4, the second quiz in week 9, and the third quiz in week 12. The complexity of the quizzes increases from assessment to assessment: while the first quiz has 5 questions and 5 minutes allocated to it, the next quiz has 6 questions (to be completed in 6 minutes), and the last quiz has 7 questions which need to be finished within 7 minutes. The quizzes conducted in the Enterprise Web Solutions course are a combination of two types of questions – multi-select questions or short-answer questions. Contrary to typical single-choice or multiple-choice quizzes, the quizzes conducted in this particular course are not targeted at memorisation and reproduction of facts or data. Rather than that, the students need to evaluate the plausibility of given statements, assess the possibility of combining different options, exclude or include various alternatives.

While the difference in the maximum marks in this particular assignment is small (FACE users vs. FACE non-users), very interesting is the pattern concerning the minimum mark achieved in this assessment.

As indicated above, the first quiz is conducted in week 4 (the FACE exercises start in week 2). Consequently, there is not much opportunity for students to practice on the non-graded exercises until the first quiz. Thus, the impact of those exercises on the actual assessment seems to be low. For quizzes conducted in weeks 9 and 12, however, the impact seems to steadily increase as the minimum mark (and, consequently, the average mark) for those assessments for students using the FACE application is consistently higher than for those students who do not use FACE (e.g., considering all terms under examination, for quiz 2, the non-users of the FACE system achieved the minimum mark of 2.0, but the FACE users the minimum mark of 3.8, for quiz 3, the non-users had the minimum mark of 2.0, the users the minimum mark of 4.1 out of 10).

To obtain some qualitative data supporting the results of the quantitative data analysis, three information focus groups were conducted with students of the course.

While the first focus group was primarily focusing on the design aspects of the tool (and led to several changes in the layout of the practicing and student-facing interface), the most important insights concerning the perceived usefulness of the tool from the students' perspective was gained through the second and third focus group.

One of the most frequently discussed aspects was the students' difficulties in getting "used" to the nature of the tool.

One of the participators of the focus group 2 formulated this aspect in the following way:

> *The most difficult thing here is to get used to the fact that the exercises are non-graded. Personally, I did not take them seriously at the beginning. I thought: I do not get a mark for this thing, so why should I be doing it?*

Another student of the same focus group added:

> *For me, it was not taking it seriously or not. I was actually afraid of doing them. I was afraid of making mistakes. I thought that somehow it will impact my grade for the course. So it took for me a long time to see that nothing bad happens if I make a mistake. That I can start over again and try to fix it.*

Most students clearly confirmed the fact that there was a considerable effort involved in getting used to the nature of the exercises and accepting the fact that those exercises are neither graded, nor taken into account when assigning the final mark for the course.

However, it seems that most students – particularly later in the course – started to appreciate the non-graded and formative character of the exercises and feedback given to those exercises. As one of the participants of the third focus group noted:

> *Towards the end of the course, I started to feel so good about those exercises. The main thing was that the pressure was gone. I knew that I have the freedom in doing them the way I like. Making mistakes ... trying out ... looking for the right answers ... yes, thinking about them.*

Moreover, the students pointed out to the fact that those exercises were particularly useful because of their online availability. In fact, most of the students stated that they continued to look at those exercises in their time outside the actual class, too, and that they used those exercises to prepare for the final exam of the course.

Additional features appreciated by students was the immediate feedback which the system returned upon each of the attempts, the possibility of monitoring own performance across several sections of the course and the accessibility of the correct answers after a specific number of attempts (although most students indicated during the focus groups that the temptation to access the correct solutions as soon as they got available considerably decreased over time – instead, most students attempted to finish the exercise without consulting the solution repository). Moreover, most students also considered the "post-exercise" review done during the subsequent class very useful for their understanding of the concepts and topics covered in class.

6 CONCLUSIONS

The current study has shown that non-graded formative online exercises have the potential to considerably improve students' understanding of complex concepts and their underlying meanings. The study has also demonstrated that such exercises are helpful in emphasizing learning and reinforcing important concepts covered in a course, and they also may be instrumental in increasing students' motivation and engagement in class.

Although the current study has been carried out in the context of Information Systems education, the insights gained through this study appear to be applicable to any higher education program which is motivated to provide students with a greater choice and ownership in their learning and which is determined to emphasize student-centered and student-focused teaching and learning.

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An Application for Marking and Analysis of Assessment Instruments in a Programing Course

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Abstract: This paper describes an MS Excel-based application to facilitate and ensure consistent and fair assessment of paper-based assessment instruments by using a very detailed marking scheme that divides each question with reference to the steps into which the answer is expected. The marks are entered into the appropriate worksheet specifically designed for each question. The application provides an in-depth analysis of students' performance against each component of the question highlighting their strengths and weaknesses in solving the individual components of the question. This application also serves as an instructional gadget enabling the instructors to provide the essential and constructive feedback to their students.

1 INTRODUCTION

In the educational assessment process, the perception of assessment varies depending on how the assessor sees the role of the assessment itself as well as the role of the assesses (Gijbels et al., 2008). Traditionally, the assessment was heavily influenced by old paradigms in which testing were not considered as an integral part of instruction (Shepard, 2000). The assessment was primarily seen as a means to determine grades; to find out to what extent students has reached the intended objectives (Gijbels et al., 2008). In recent years, the assessment perception has changed significantly. The most fundamental change in the view of assessment is represented by the notion of 'assessment as tool for learning' (McDowell and Dochy, 1997). Good and meaningful feedback containing high quality information to students about their learning helps students become more aware of their strengths and weaknesses that enables them to take steps to address deficiencies in their own learning (Pintrich, 1995).

As educational institutions are increasingly held accountable for student learning (Braathen and Robles, 2000) and a meaningful assessment represents an important measure to respond to such accountability. The student assessment conducted solely for accountability reasons does not necessarily lead to learning. Educators must establish the purpose of assessment, the criteria being measured, and the intended outcomes before meaningful assessment methods can be achieved (Gaytan, 2002). The purpose of assessment is to monitor student learning, improve academic programs, and enhance teaching and learning and student satisfaction.

In the modern era of Information Technology, computer-based assessments have grown in popularity. Computer assisted assessment (CAA) is an important example amongst this category of assessment. Sim et al (2004) describe CAA as the delivery, marking or analysis of assignment or exams using computers. Due to their accuracy and speed of execution, they are predicted to become the primary mode of assessment in the future (Wang et al., 2007). A lot of work is being done for online assessment largely comprising of multiple-choice questions. Furthermore, the computer-based assessment is highly reliable and consistent (Scholtz, 2007) unlike human assessments that are influenced by an assessor's mood, interpretation and understanding. In spite of all these developments, most of the assessment instruments (tests, quizzez, examination, etc.) are still being conducted in paper-based format that are prune to variety of challenges which may affect the fair evaluation of such instruments.

From the authors' experience, critical analysis of marking of paper-based assessment instruments have revealed occasional difference in marks awarded for two similar answers of a question in two answer scripts confirming the above mentioned influences discussed earlier. Most academic institutions have a policy of showing marked assessment instruments to respective students so that they can review their marks and the feedback provided by their instructors. The students also compare their papers with each other and then approach to their instructor for any potential disparity in marking of similar answers. In classes with large number of students, it is quite difficult for instructors to address the students' concerns in a satisfying manner. Therefore, there is a need to develop a tool or application that could facilitate instructors to evaluate students' work by allowing instructors to award marks in a fair and consistent manner while providing valuable feedback to the students.

Section 2 deals with the proposed application and related details of the worksheets. A detailed discussion is provided in section 3 whereas the conclusion of the paper is given in section 4.

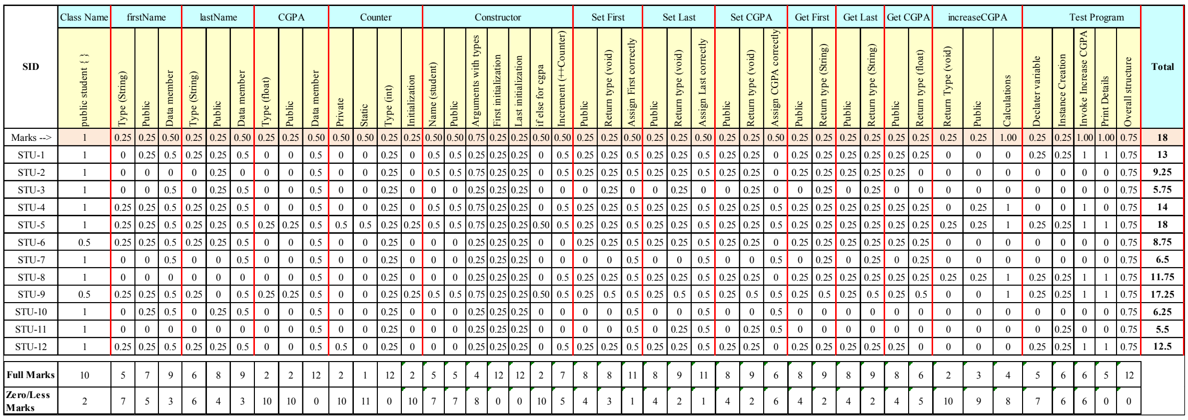
2 PROPOSED APPLICATION

This paper proposes an MS Excel-based application to facilitate the evaluation and marking of paper-based examination papers. This application comprises of a workbook in MS Excel 2010 having one worksheet for each question in the examination paper for which the application is required to be used. Each worksheet incorporates the summary of each question providing complete details of the marks distribution and allows the instructor to enter the data at the time of evaluating the students' answers. Once the data is entered in the worksheet, the application automatically analyses the students' evaluation data and generates graphs that provide a complete analytical picture of the students' performance for each component of the question of the examination paper.

We will explain this application by using a real example taken from questions from one of the assessment instrument conducted for a course entitled "Advanced Programing through Java" offered as a part of an undergraduate engineering degree program. The example taken to explain the functionality of the proposed application is a question statement from the selected examination paper carrying eighteen (18) marks. The question statement is given below.

> "Create a class called Student that includes three pieces of information as instance variables — a first name, a last name, and CGPA. The student class also includes a class level variable counter that keeps the record of student's objects created. The Student class should have a constructor that initializes the three instance variables. Provide a set and a get method for each instance variable. If CGPA is not positive, set it to 0.0. This class includes a method IncreaseCGPA that increases the CGPA to 2.0 for the students whose CGPA is in the range 1.995 - 1.999.
>
> Write a test application named StudentTest that demonstrates class Student's capabilities. Create two Student objects and display each object's CGPA. Invoke the IncreaseCGPA method on each object and print the details again."

Considering the importance of each component in the above stated question, the marking scheme (distribution of marks) is shown in Figure 1.



SID	Class Name	firstName			lastName			CGPA			Counter				Constructor							Set First			Set Last			Set CGPA			Get First		Get Last		Get CGPA		increaseCGPA			Test Program					Total
	public student { }	Type (String)	Public	Data member	Type (String)	Public	Data member	Type (float)	Public	Data member	Private	Static	Type (int)	Initialization	Name (student)	Public	Arguments with types	First initialization	Last initialization	if else for cgpa	Increment (++Counter)	Public	Return type (void)	Assign First correctly	Public	Return type (void)	Assign Last correctly	Public	Return type (void)	Assign CGPA correctly	Public	Return type (String)	Public	Return type (String)	Public	Return type (float)	Return Type (void)	Public	Calculations	Declater variable	Instance Creation	Invoke Increase CGPA	Print Details	Overall structure	
Marks -->	1	0.25	0.25	0.50	0.25	0.25	0.50	0.25	0.25	0.50	0.50	0.50	0.25	0.25	0.50	0.50	0.75	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.25	0.25	0.50	0.25	0.25	0.50	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	0.25	0.25	1.00	1.00	0.75	**18**
STU-1	1	0	0.25	0.5	0.25	0.25	0.5	0	0	0.5	0	0	0.25	0	0.5	0.5	0.25	0.25	0.25	0	0.5	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.25	0	0.25	0.25	0.25	0.25	0.25	0.25	0	0	0	0.25	0.25	1	1	0.75	**13**
STU-2	1	0	0	0	0	0.25	0	0	0	0.5	0	0	0.25	0	0.5	0.5	0.75	0.25	0.25	0	0.5	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.25	0	0.25	0.25	0.25	0.25	0.25	0	0	0	0	0	0	0	0	0.75	**9.25**
STU-3	1	0	0	0.5	0	0.25	0.5	0	0	0.5	0	0	0.25	0	0	0	0.25	0.25	0.25	0	0	0	0.25	0	0	0.25	0	0	0.25	0	0	0.25	0	0.25	0	0	0	0	0	0	0	0	0	0.75	**5.75**
STU-4	1	0.25	0.25	0.5	0.25	0.25	0.5	0	0	0.5	0	0	0.25	0	0.5	0.5	0.75	0.25	0.25	0	0.5	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.25	0.25	0.25	0.25	0.25	0	0.25	1	0	0	1	0	0.75	**14**
STU-5	1	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.25	0.5	0.5	0.5	0.25	0.25	0.5	0.5	0.75	0.25	0.25	0.50	0.5	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	0.25	0.25	1	1	0.75	**18**
STU-6	0.5	0.25	0.25	0.5	0.25	0.25	0.5	0	0	0.5	0	0	0.25	0	0	0	0.25	0.25	0.25	0	0	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.25	0	0.25	0.25	0.25	0.25	0.25	0.25	0	0	0	0	0	0	0	0.75	**8.75**
STU-7	1	0	0	0.5	0	0	0.5	0	0	0.5	0	0	0.25	0	0	0	0.25	0.25	0.25	0	0	0	0	0.5	0	0	0.5	0	0	0.5	0	0.25	0	0.25	0	0.25	0	0	0	0	0	0	0	0.75	**6.5**
STU-8	1	0	0	0	0	0	0	0	0	0.5	0	0	0.25	0	0	0	0.25	0.25	0.25	0	0.5	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.25	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	0.25	0.25	1	1	0.75	**11.75**
STU-9	0.5	0.25	0.25	0.5	0.25	0	0.5	0.25	0.25	0.5	0	0	0.25	0.25	0.5	0.5	0.75	0.25	0.25	0.50	0.5	0.25	0.5	0.5	0.25	0.5	0.5	0.25	0.5	0.5	0.25	0.5	0.25	0.5	0.25	0.5	0	0	1	0.25	0.25	1	1	0.75	**17.25**
STU-10	1	0	0.25	0.5	0	0.25	0.5	0	0	0.5	0	0	0.25	0	0	0	0.25	0.25	0.25	0	0	0	0	0.5	0	0	0.5	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	**6.25**
STU-11	1	0	0	0	0	0	0	0	0	0.5	0	0	0.25	0	0	0	0.25	0.25	0.25	0	0	0	0	0.5	0	0.25	0.5	0	0.25	0.5	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0.75	**5.5**
STU-12	1	0.25	0.25	0.5	0.25	0.25	0.5	0	0	0.5	0.5	0	0.25	0	0	0	0.25	0.25	0.25	0	0.5	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.25	0	0.25	0.25	0.25	0.25	0.25	0	0	0	0	0.25	0.25	1	1	0.75	**12.5**
Full Marks	10	5	7	9	6	8	9	2	2	12	2	1	12	2	5	5	4	12	12	2	7	8	8	11	8	9	11	8	9	6	8	9	8	9	8	6	2	3	4	5	6	6	5	12	
Zero/Less Marks	2	7	5	3	6	4	3	10	10	0	10	11	0	10	7	7	8	0	0	10	5	4	3	1	4	2	1	4	2	6	4	2	4	2	4	5	10	9	8	7	6	6	0	0	

Figure 1: Students' Marks Snapshot.

This question can be broken down into its component items listed in the first row of the Figure 1 (i.e. Class Name, First Name, etc.).

These components are essentially the items in the 'class' which are further divided into parts (listed in row 2) for the purpose of micro-level marking of students' answers. A class in an object-oriented program is a basic element and comprises of field names normally called data and methods called behavior. The class name is given one mark if student defines a class correctly i.e. There are three fields required in the question. The fields (data members) have data type and name in addition to the access modifier i.e. private, public, protected or static. There is one (01) mark for each data member if it is defined correctly i.e. private String *firstName*;. The correct data type and access modifier private are given 0.25 marks each. If correct data type and/or correct access modifier is not used but data member is defined in the class then 0.50 marks will be given. The CGPA field could take values from 0.0 – 4.0 which required it to be of float data type with private access modifier.

A class level field has only one copy in the class and is declared static, private, and initialized while declaring it. The 'counter' field asked in this question is to judge this knowledge of the students. We allocated 0.5 marks for declaring it static, 0.5 marks for private access modifier, 0.25 marks for *int* data type and 0.25 marks its initialization to 0. We did not allocate marks for its initialization and data type.

A constructor in a class is a very important method used to create objects of the class. The acceptable constructor definition of the student class is given below.

```
public student (String first, String
                      last, float cgpa)
{
   firstName = first; ------------- 1
   lastName = last; --------------- 2
   if(cgpa < 0) ------------------- 3
      CGPA = 0;
   else
      CGPA = cgpa;
   ++counter; --------------------- 4
}
```

Based on the above definition of the constructor, we allocated 0.25 marks to the keyword public, 0.25 marks for constructor name same as the class name, 0.25 marks for each argument in constructor and 0.25 marks for line 1 and line 2. We gave 0.50 marks to line 3 i.e. to allocate positive value to the CGPA because it tests the students' skill to use double-selection construct already taught at introductory programing course which is a prerequisite of this advanced level course. We allocated 0.50 marks to ++counter; statement at line 4.

There are 'get methods' in a class to retrieve the values of data field and 'set methods' to set the values of data fields. Since there are four data fields in this class therefore at least there should be four set and four get methods. All set method normally have return type void and argument type same as of the field of which it will set the values and the get methods have same return type as of the field of which it returns the value without any parameter. As an example, one set and one get method of the class is given below.

```
public void setFirst(String first){
firstName = first;
}
public String getLast(){
return lastName;
}
```

In set method we allocated 0.25 marks for the keyword public and 0.25 marks for the correct data type of the argument and 0.50 marks for correctly assigning value in the argument to the data field i.e. *First* in this case. In the get method we allocated 0.25 marks to the keyword void and 0.25 marks for returning the correct data field value.

An important part of the question is to write a method '*IncreaseCGPA*' to increase the CGPA of a student to 2.0 who's CGPA is 1.995 or greater but less than 2.0 as shown below.

```
public void IncreaseCGPA(){
   if(CGPA >= 1.995 && CGPA < 2.0)
   CGPA = 2.0;
}
```

We allocated 2.0 marks in total to this method; 0.25 for public keyword, 0.25 for void return type and one (1.0) mark for if else construct correctly used in this method.

The last part of the question is to test the students' abilities to use the class defined. The student should know how objects of a class are created and methods are invoked. We have allocated three (3) marks in total to this part; 0.5 marks to the main structure of the program, 0.25 marks for declaring variables of class '*student*', 0.25 marks for using constructor correctly and initializing it to the variable. One (1) mark has been allocated to invoke the '*increaseCGPA*' method on one the objects. Finally, one (1) mark has been allocated to print the objects details through method defined in the class or directly accessing the ‘get methods’ in the main program.

We have created a workbook in MS Excel 2010 having one worksheet for each question in the selected examination paper. A worksheet contains the summary of each question providing complete details of the marks distribution. For each question, we open the worksheet, take each paper, and fill each cell that shows the allocated marks of each item of the question to be evaluated. Moreover, the program is written according to the items as listed in Figure 1. This application facilitates instructors in assessing each student’s question paper in a fair and consistent manner along with other knowledge that is discussed in the next section.

3 DISCUSSION

Though the analysis of each question with a detailed marks distribution and the development of such worksheets is time consuming and tedious task, however, it is worthy of the effort both for assessing the students’ performance in different programing skills at micro level and reviewing the lecture methodology in order to address the weak skill(s) of the students. The analysis of class fields’ declaration For example, in Figure 2, approximately 16% of the class could assign correct data type i.e. float to the CGPA data member and 84% of the class assigned either integer (int) or any other data type.

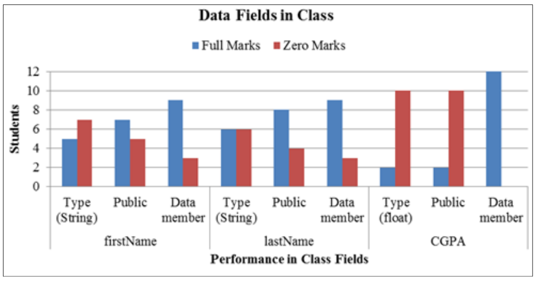


Figure 2: Class Fields Performance.

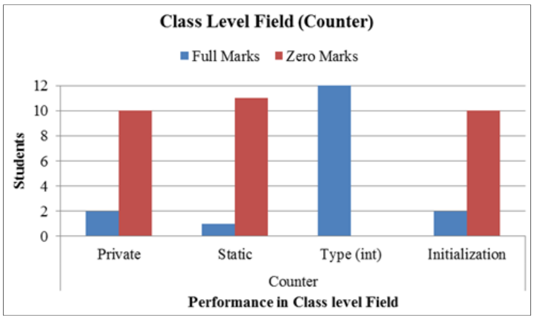


Figure 3: Class Level Field’s Performance.

This analysis of class fields guides the instructor to concentrate on students’ skill of defining the correct data fields in a class. The performance of students is poor in defining the class level field i.e. counter in class student as shown in Figure 3. All of the students managed to put this field in the class but failed to assign the access modifier, declaring it class level data by using static keyword and initialized to zero (0) i.e. private static int counter = 0; as shown in Figure 3. This analysis compels the instructors to give more time on this item during tutorial sessions for the course before moving to the next topics of the course.

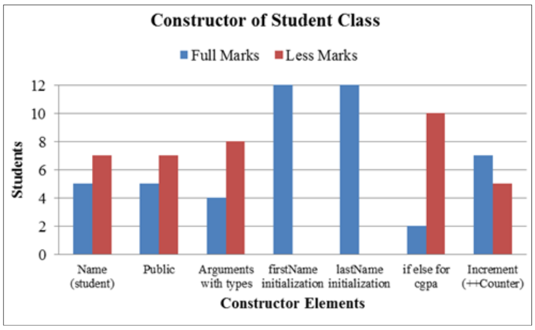


Figure 4: Constructor Performance.

The application helps the instructor to analyse another important component ‘the constructor’ in object-oriented programing. This requires that class name should be the name of this method and it should be declared public. All the arguments should have the same data type as of the fields in the class. There should not be argument for class level fields. While associating arguments to the fields for CGPA it is important to test its value; if negative then assign zero (0) to the CGPA field else assign the value in the argument. We see from the analysis in Figure 4 that two data members ‘firstName’ and ‘lastName’ have been assigned the arguments correctly. However, students’ performance in assigning argument to data members which require some analytical skills is not appreciable.

The analysis of students’ performance in ‘set methods’ used to set the values of fields of a class is shown in Figure 5. All such methods must be declared public and since these methods will set values of the class fields and will have return type ‘void’. These will have same data type for each argument as of respective field in the class. The analysis shows that performance is better as compared to other parts of the class except for setting values to CGPA. The instructor can review and devise his strategy to refine the weak skills of students such as using if else selection structure.

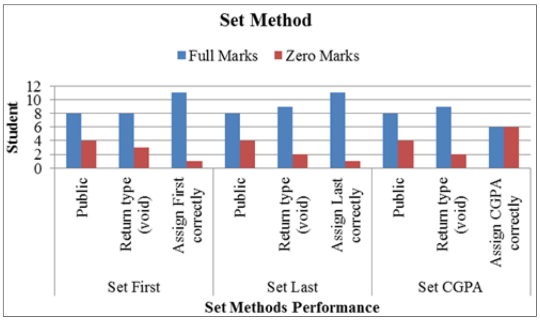


Figure 5: Set Methods Performance.

A method to increase the CGPA of students to 2.0 who have CGPA in the range 1.995 – 1.999 is asked in the question. This is an important method that requires skills of using single-selection ‘if’ and combining the conditions ‘&&’ learned in the pre-requisite course. Again, the performance is not very encouraging in this method as evident from Figure 6. This type of analysis is quite useful for providing feedback to the instructor responsible for the teaching of the pre-requisite course.

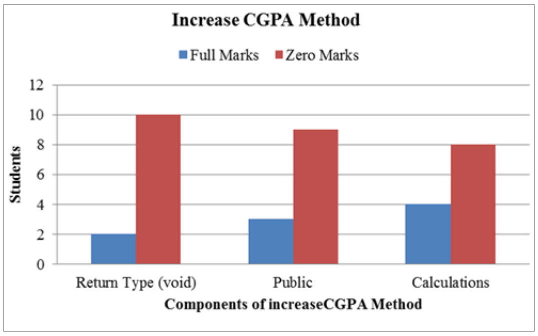


Figure 6: Increase CGPA Method Performance.

Finally, we discuss the performance of students in using the class student in main program by creating objects of the class student and then invoking method on an object and printing the details of an object. The students’ performance in this area is shown in Figure 7. The students’ performance using class student in main program is fifty-fifty. The students showed 100% performance in overall structure of the main program which is expected in each part in defining a basic component of object-oriented programing.

The application appears to be very complex as one may see the worksheet of the MS Excel-based system as difficult to manage because the instructors are required to record the data for each small component of different questions and then enter this data into the worksheets. In spite of this hard work, the authors’ experience show that this application is a very convenient way of marking the students’ answers in an consistent and fair manner. The authors have been using similar application for assessing the students’ performance in other courses offered in the engineering degree program.

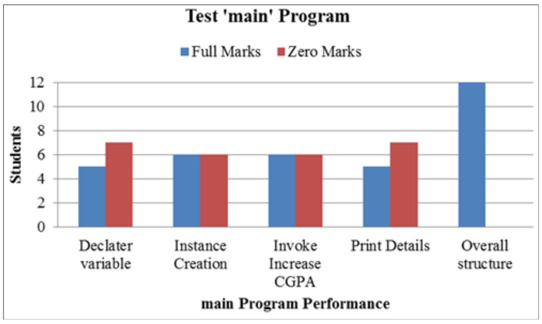


Figure 7: Test 'Main' Program Performance.

The application has also provided us a deep insight of each topic taught and assessed in a course at micro level and helps us in devising the appropriate strategy or mechanism to address the weaknesses of the students. The application also facilitates instructors to compile and run the program successfully and provide the solution to the students for comparison with their own answers as well as allow them to use this micro level insight of their answers to overcome their weaker skills. In our experience, the application has also reduced the number of post-marking queries from the students about their dissatisfaction on their grades.

4 CONCLUSIONS

We have developed and used an MS Excel-based application for fair and consistent marking of assessment instrument in a programing course in a degree program. This helped the authors in reviewing lecture materials and teaching methodologies and concentrating on skills in which students’ performance was weak. It reduced the students’ queries and increased their confidence in the grading of their work.

This application could be upgraded to an automated system for creating and grading the assessment instruments through instructor-friendly graphical user interfaces. The system will also provide an appropriate customised feedback to individual students and the relevant instructors.

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Three Years of Teaching using Collaborative Tools
Patterns and Lessons Learned

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Keywords: Programming Learning, Collaborative Editing, Wiki, Flip Teaching.

Abstract: The author has taught computer science (Programming 101 and Operating Systems 101) for about fifteen years. He introduced the use of a student-collaborated wiki website for his courses about ten years ago. Then, three years ago, he also began extensively using a collaborative editor (Gobby) in classroom, to let students actively participate during lessons. This paper describes the author's course "workflow", summarizes tools (wiki and collaborative editor) functionalities, collects some context pattern and tries to draw a few conclusions (lessons learned) about the course methodology.

1 INTRODUCTION

The author of this paper is currently teaching Computer Programming 101 at an italian University. He has taught alternatively Computer Programming and Operating Systems for more than fifteen years. He is also the founder of a Laboratory on Free Software.

The Programming 101 course is organized using a fairly standard structure: 1) traditional "frontal" lesson time, with blackboard, slides and projector and 2) traditional (before introducing the system described here) lab time, with a PC for every student, a programming environment with online documentation and... blackboard, slides, and projector again. We use GNU/Linux as our main operating system so that our students, mainly coming from previous (if any) experiences with Windows or Mac, are immersed in a different and unfamiliar environment, in the (often vain, alas) hope to wake them and spark some curiosity about the internals of an operating system and about programming besides windows, mouses and the damages of autocompletion. We adopted Java for the Programming 101 course even if there has always been some debate over using an Object Oriented language as the first language [(Clark et al., 1998), (Hadjerrouit, 1998), (Hosch, 1996) and (Pears et al., 2007)], we are trying to introduce advanced language concepts as soon as possible. Our course is a bit crowded (just less than 200 students) so we usually split labs into three turns. Classrooms are standard: about 50 PCs, GNU/Linux, (almost full) network access, overhead projectors and a PA audio system. Since the beginning of his work in teaching, the author (inspired by the F/OSS (Free/OpenSourceSoftware) communities where collaboration is the main "tool" to achieve a goal) started using collaborative tools to let students participate in the learning process. The first tool was a **wiki** (description in 2) website. Then, about three years ago (academic years: 10-11, 11-12, 12-13), the author introduced and began extensively using a **collaborative editor** (Gobby, more in 2) in classroom, during lessons.

2 TOOLS

A **wiki**(-website)[1] is a website that can be modified by its readers/users. Wikipedia is the most famous one of course, but there are probably millions of almost unknown wikis scattered through the Internet. A wiki is a convenient way of sharing knowledge in a community: any member of the community can add/modify/delete/upload/etc. the set of available pages, thus augmenting, refining, ameliorating the knowledge base of the community itself. A wiki website can be set up in a matter of minutes, there are versions written in almost every language ever invented on earth[2]. Editing is done using a very simple and easy to learn tagged language, sometimes resembling HTML. Software policies allow the wiki maintainer to tune edit permissions, i.e. giving read/write/etc.

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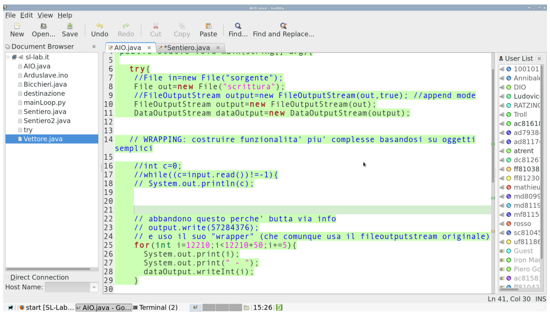
[1] http://en.wikipedia.org/wiki/Wiki

[2] http://en.wikipedia.org/wiki/List_of_wiki_software



```

  try{
    //File in=new File("sorgente");
    File out=new File("scrittura");
    //FileOutputStream output=new FileOutputStream(out,true); //append mode
    FileOutputStream output=new FileOutputStream(out);
    DataOutputStream dataOutput=new DataOutputStream(output);


  // WRAPPING: costruire funzionalita' piu' complesse basandosi su oggetti semplici

    //int c=0;
    //while((c=input.read())!=-1){
    // System.out.println(c);



    // abbandono questo perche' butta via info
    // output.write(57284376);
    // e uso il suo "wrapper" (che comunque usa il fileoutputstream originale)
    for(int i=12210;i<12210+50;i+=5){
      System.out.print(i);
      System.out.print(" - ");
      dataOutput.writeInt(i);
    }

```

Figure 1: The Gobby editor.

rights to users. In the author's case, his course wiki is configured to let any student contribute upon registration. For the sake of completeness the author's choice for wiki software goes to DokuWiki[3].

The **Gobby**[4] editor (see Figure 1) is a "collaborative" editor. The word "collaborative" means that this editor can be simultaneously used by a group of people, potentially located far away from one another, to edit files together, everyone seeing and interacting on each other's work. For a group to work togehter someone must install a server that must be reachable by everybody through the Internet. Then every member of the group must connect to that server and, if the connection does not fail, a new user (a self-assigned unique nickname is required) appears in the "user list" of every Gobby client connected to that server. Users are assigned a unique colour because every edit action is colour marked. Selection actions of other users are shown, so that any user can have a look at "what others are looking at or doing". When switching to a particular file, on the righthandside of the Gobby user interface there is a list of the users currently editing that file, the file-users association is many-to-many. The main editing area is in the centre while on the left there is a list of available servers and open documents. On the bottom of the window a chat area (not shown in Figure 1) can be activated, it is mostly used during long distance session to coordinate editing ("out of band" communication). Any user can locally save any file at any moment, this is a perfect fit for a collaborative programming environment since anybody can save and compile on its own to verify errors or the correct execution of the source code of the program under examination. There is also a recently introduced *undo* function. Gobby supports language syntax colour coding. The current version does not support any kind of formal coordination, i.e. different roles in a group of users, for example to manage some kind of "ask permission to edit", "edit approval", etc.

In classroom, the author's workflow goes like this: 1) launch the server; 2) tell everybody the *url* to connect to and wait for them to complete; 3) start editing a source file; 4) speak while showing various programming examples; 5) let the students add/modify the code **guiding** them by voice (see 3).

Alternatives: the previous (pre 0.5) versions of Gobby were far form perfect so at one point we had some brief experience with "google docs/google drive" which is a cloud application server enabling users to create and share various types of documents, e.g. formatted text documents, spreadsheets, presentations, etc. The overall functionality is almost the same (usernames, colours, multiple simultaneous editing, etc.) but the main disadvantages are that: 1) it is oriented towards **formatted** documents[5]; 2) every piece of information is managed by Google while the infinoted server is installed locally. Also, some colleagues use *git*[6] as a collaborative platform, but in that case the collaboration is not interactive.

3 PATTERNS

First, a brief note about our course **wiki** usage during these ten years, then the rest of this section will delve into some analysis about collaborative editing patterns. Alas, the wiki is in fact almost only used as a conventional website. I.e. in terms of contributions there are very few students that "dare" to edit what the teacher puts online. And this trend is worsening: while a few years ago there were at least a couple of students for each course who edited and contributed, this year the number of editors is still zero (they haven't even registered), and we are at 75% course completion. There are too many factors involved to draw some conclusion about the cause(s) of this decrement, one of them could of course be the diminished ability of the teacher to spread enthusiasm among the students... some quantitative study should be undertaken before worrying. On the other hand, the usage of **Gobby** in the classroom has got a foothold among the students, there are always at least five of them (on an average attendance of 25[7]) actively interacting with the author. This wide ap-

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[3] https://www.dokuwiki.org

[4] http://gobby.0x539.de

[5] They can be exported to a text only file (loosing comments and any metatext) and there is no language syntax color coding

[6] http://git-scm.com/ a distributed version control system created by Linus Torvalds

[7] We do not oblige students to attend lessons and it is common to all courses to observe a natural decay in attendance: from 100% for the first couple of lessons to the average 50% for the rest of the course

preciation has led the author to a fair grade of usage standardization (“routine”) and to the identification of a few **patterns** described in the following sections.

=> **Pattern: “think ahead”**
They in fact interact so much that the author must tell them to wait before writing some final snippet of code because he wants to show them every step, even wrong ones. They are sometimes thinking ahead of the teacher, at least in terms of the final solution to a problem, but since this is a programming course they must be exposed also to common mistakes.

=> **Pattern: “leave traces for future reference”**
To keep every snippet of code, even wrong (or just worse) ones we decided to leave every significant code statement inside the current example just by commenting out the ones we do not want to be compiled. The following is a very small example of the way we organize examples by leaving common mistakes in the code itself:

```
// this is done right
Random r=new Random();
for(..;..;..) {
 ...
 r.nextInt();
 ...}
// this one stresses the GC
/* for(..;..;..) {
 Random r=new Random();
 ...
 r.nextInt();
 ...} */
```

The second half is commented out using standard Java syntax: “//” and “/* .. */”. This way they can study every possible solution in a single compilable example code. It is a kind of *poor man’s version control*: by commenting and decommenting lines students can experiment with different “versions”. It may also be useful to have some kind of visual branching tool to show different solutions to the same problem with different code snippets, but it is the author opinion that it would also complicate too much the interface of Gobby itself.

=> **Pattern: “out-of-band... inline”**
Instead of using the (out-of-band[8]) chat to coordinate and to ask questions, we ended up inlining questions and comments using... code comments (again). While the author is writing - and explaining/commenting by voice - some example code, students prepare questions and comment simultaneously by using standard Java comments. So that any answer, be it in form of a code snippet (thus in the code and compilable) or text (thus in a following comment) remains strongly attached to the code that stimulated the question itself. By the way, at the end of every session all the code created during the lesson is usually uploaded to the wiki.

=> **Pattern: “emergent syntax”**
Sometimes there is a need to communicate “graphically” and, since Gobby does not support anything other than text we have to resort to the good old ASCII art[9], albeit very simple and naive, like:

```
// <<<===  see other doc in the list!
```

Or:

```
Stringhe di comando
|-D(igital)
|      \
|       |-I-pinNumber [ritorna valore]
|       |-O-pinNumber-H/L
|-A(nalog)
|      \
|       |-I-pinNumber [ritorna valore]
|       |-O-pinNumber-value
|-V(ersion) [ritorna valore]
|-NP(umber of pins)  [ritorna valore]
```

Or:

```
SCHEMA
(Client)                (Server)
Socket              other Socket
|-InputStream  <= OutputStream-|
|-OutputStream =>  InputStream-|
```

Everything is always left in the code (thus in the wiki) for future reference. In one single compilable file students can find examples, comments, questions, answers, common mistakes, different solutions to the same problem, and they participated in building that content.

=> **Pattern: “pillory demythified”**
Sometimes the author gives an exercise in the classroom to be solved by the students themselves. When a resonable (to complete the exercise) amount of time has passed the author *jokingly* asks if any of them wants to be “put in the pillory” by copying & pasting their code in public, reassuring them that if there are mistakes it will be a better chance for everybody to learn. And it works! There is usually no need to force anybody to “volunteer” their code, there is always one or two of them willing to show their work. Humour is a good way to lower their fear. And using their code instead of the teacher’s is a better chance to discuss about different solutions and about common mistakes, and the ones who learn more are the ones offering their code since they are more involved of course.

=> **Pattern: “correct as the teacher speaks”**
The author frequently introduces common programming mistakes and asks the students to find them. Then he leaves the keyboard and starts speaking and

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[8] http://en.wikipedia.org/wiki/Out-of-band

[9] http://en.wikipedia.org/wiki/ASCII_art

explaining (maybe pointing at something on the projected screen), trying to lead the classroom towards the correct solution. Usually, while the teacher is speaking they correct the errors (leaving, i.e. commenting out, wrong pieces of code for future reference) on the fly so that the visual effect (just looking at the projector) is similar to a vocal interaction between the teacher and a programming environment. The advantage in this case is that the teacher has good feedback on the students understanding level. Why? Because the speed and quality of their corrections is an immediate and direct measure of their ability to discuss about programming Moreover the author believes they grasp better since they can interact with the ongoing reasoning.

=> **Pattern: "humorous relief"** When in need of a coffee break they comment in the code:

```
// COFFEE!!!
```

And the teacher usually may comment like this:

```
// in five minutes, let me finish this example
```

I.e. there is a lowered authorithy gap while writing, people usually dare a little more in written form (such as in chats or in this collaborative editing case) than in person.

4 CONCLUSIONS

The first lesson learned by the author is that "fully opening" the teaching loop to students intervention completely changes the way teaching must be addressed: since there cannot be strictly fixed and prepared learning material (just a general lesson goal that must be achieved) the teacher must be much more flexible and prepared (e.g. the number of questions raised is far higher than during a standard lab lesson) to any path the students are willing to follow. With limitations of course: the teacher must be very good at leading them where he wants to bring them. The teacher must earn his authority in the field - "the hackers way" (Levy, 2001) - his ability and knowledge is put more to the test in this context. The teacher must also be more open to suggestions, needs, curiosities and of course criticisms raised by the students. And this approach stimulates more curiosity: students can become very knowledge greedy. The most important and useful habit the author has acquired during these years is the "declaration of methodology", the complete disclosure of the approach used, even at the meta level: i.e. the author explains in classroom almost every pattern described in this paper and discusses with the students any form of possible amelioration of the teacher-student interaction.

The approach described (and also proposed) here is a very light kind of "flip teaching" since our students are still exposed first to traditional theory and next they have to apply the theory during a very interactive lab. This way of teaching is at the opposite end from the traditional (blackboard and slides) lesson and it also represents, according to the author of course, a progress with respect to the traditional lab lesson (in which the teacher "gives work" and then circulates among students to help them singularly) because it does stimulate interaction (as in a standard lab) but it also **shares/spread** this interaction among all the students in the classroom. Other interesting learning patterns can be found in (Flood and Lockhart, 2005) and (Hickey et al., 2005), some of them based on student debate, they also could be applied through gobby, the author will try to bring the most useful ones in his classroom. This approach is lightly coupled to any particular programming language, for patterns more related to programming concepts the interested reader may start from (Gomez-Albarran, 2005), a survey of tools for learning (visualization, animation, etc.).

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Problem-based Virtual World Design for Virtual Reality Education

An Experiment with the Opensimulator Platform for Second Life-based Virtual Worlds

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Keywords: Virtual Reality, Problem-based Learning, Virtual World, Second Life, Opensimulator.

Abstract: In this paper we present our current efforts with a novel, problem-based learning paradigm for academic-level education on topics related to Virtual Reality. The paradigm embraces problem-based learning principles and methods, adopts methodologies and technologies pertaining to the Second Life online virtual environment and relies on the use of exclusively free software, namely, the OpenSimulator platform for Second Life-based virtual environments. We have applied the paradigm for the purposes of a BSc-level course module on Virtual Reality and have evaluated its educational impact and appeal to students through a questionnaire-based survey.

1 INTRODUCTION

Virtual Reality is the scientific field whose object is the design and operation of virtual worlds. Virtual Reality has numerous applications, in fields such as simulation, entertainment, art, education and others.

Thanks to its capacity to support complex, dynamic and, recently, shared simulations with online access capabilities, Virtual Reality is an ideal option for educational applications. However, even though Virtual Reality has been put to actual use as an educational aid extensively until today, its potential as a means to teach, and practice with, topics related to Virtual Reality itself, including virtual world design, real-world application, technical administration, product promotion, etc., does not seem to have been as thoroughly investigated.

In this paper we present our current efforts with a novel, problem-based educational paradigm (Barrett and Moore, 2010) aiming to advance academic-level teaching of Virtual Reality-related topics. The proposed paradigm relies on the use of shared virtual worlds accessible online and realized using exclusively free software – namely, the OpenSimulator platform for Second Life-based virtual environments (OpenSimulator, 2012) – and has a strong focus on self-directed learning, collaboration and well-meant competition. We have applied the proposed paradigm in the context of a BSc-level course module on Virtual Reality during the academic year of 2011-2012 in the Department of Informatics, University of Piraeus, Greece.

2 RELATED WORK

Relatively recent technological advances in Virtual Reality have enabled non-expert user access to large-scale, multi-user virtual virtual worlds, such as Second Life. Due to that and thanks to a range of representation and interaction abilities, Virtual Reality has been, and is still being, extensively used as an educational aid, in areas such as training (Johnson et al., 1998), tutoring (Aylett et al., 2005), childcare (Albin-Clark et al., 2012), and others. In several cases there is specific focus on problem-based learning (for example, machinima production in Second Life (Brown et al., 2008), human-computer interaction education (Koutsabasis and Vosinakis, 2012), and others).

However, the potential of Virtual Reality applications as learning grounds for topics related to Virtual Reality itself as a scientific field, such as application life-cycle management, collaborative virtual world design, administration and operation, product promotion, etc., does not seem to have been thoroughly investigated. Attempts involving game engines such as the Unreal Engine and the Unity Engine have been employed on occasion; however, these are burdened by the fact that they demand a high level of technical expertise and platform-specific knowledge from students, which has a negative impact on the educational process as it diverges the students' attention to technicalities.

3 METHODOLOGY

Our motivation behind the educational paradigm presented in this paper was to provide students with all skills necessary to be able to address real-world situations in which the desired outcome is a virtual world, or a part of a virtual world, of specific and actual practical and, perhaps, commercial, value. These skills include the ability to:

1. plan the entire endeavour, from the initial requirement analysis to design, implementation and final presentation,
2. allocate and make optimal use of all required resources, including software, virtual world space, virtual world design assets, programming elements, time and human collaborators,
3. coordinate a team of collaborators working remotely and on diverse locations not attached to any sense of office space,
4. provide early evidence to the client party (contractor, instructor, etc.) in support of the endeavour's timely and effective progression as well as its success potential, and
5. present the final product to the client party, making clear that all original goals were attained and ensuring the party's full ability to benefit from the product as originally intended.

To that end, we adopted a problem-based learning approach for term assignments given to students of a BSc-level course module on Virtual Reality during the academic year of 2011-2012, which builds upon the following key factors:

1. Students were to work in teams of no more than 3 members.
2. Each team was to select a theme, without any restriction whatsoever imposed by the instructors, and commit to its realization.
3. Each team was allocated a specific area inside a persistent, shared virtual world accessible over the Internet, in which all teams could watch the efforts of their colleagues, communicate with everyone in the virtual world, exchange ideas and even adopt observed practices if they found them to be suitable for their own purposes.
4. Each team was to make key design decisions with a considerable potential impact on their success, in compliance with specific (but minimal) restrictions given during class. These decisions include design contracts, aesthetic options, functionality and means of interaction with the virtual world, additional multimedia content and building methodologies.
5. All teams were to adhere to common-sense fair-use practices: They were not to interfere with the work of their colleagues in any way and to not abuse the virtual world infrastructure according to specific guidelines presented to them during class.
6. Each team was to designate and commit to their own collaboration, communication and scheduling contracts.

Our intention with the above approach was to stir a strong feeling of responsibility and personal involvement with the success of a specific goal in each individual student, as well as to stress the importance of collaborative practices, both within the team as well as among teams.

Our virtual world infrastructure was based on OpenSimulator platform, an open-source, multi-platform, multi-user 3D application server based on the Second Life online virtual environment and available as free software. Students were given the opportunity to select their building areas on their own, on a first-come-first-served basis. We also reserved a central area for facilities to be used for teaching, demonstration, and information channelling purposes. All students were given precise details about how their assignments would be evaluated according to concepts and criteria presented and discussed during class. These include originality of the theme chosen, consistency with the chosen theme, design precision, compactness of the final product, variety of available means to interact with the virtual world, practical application potential and the degree to which the final product would succeed in generating an overall, subjective feeling of presence, interest, purpose and continuity to users experiencing it on their own.

4 RESULTS AND EVALUATION

During the term, we were pleased to see that most students began working quite early and on the basis of solid team-level coordination. Their involvement was constant throughout the time the virtual world was available, while their selection of subjects as well as their design and implementation approaches were diverse and imaginative.

Overall, the students' enthusiasm and the diversity and quality of their work provided us with strong evidence for the success of the approach and its suitability as a means for academic-level education on Virtual Reality-related issues. However, in order to attain a more precise and thorough understanding of whether students felt the approach was beneficial (or not) on a number of different levels as well as how various factors had a positive or negative impact on their work and ability to fully benefit from the approach, we carried-out a questionnaire-based survey on a total of 58 students.

Each questionnaire contained 35 questions which were selected with an aim to identify the students' overall impression and feelings about the approach in general, as well as the perceived educational impact, the inherent elements of cooperation and competition, the concurrent online accessibility and remote-work model, the compatibility of the approach with an academic curriculum and its suitability and effectiveness as an educational methodology, the availability of documentation and educational resources, and the technical issues they faced during their efforts. More specifically:

- 100% of the students answered that they found the experience an overall pleasant one with 84% strongly arguing that that was the case. This is, of course, a very encouraging outcome, albeit unreliable on its own: further investigation must provide a clear picture on exactly why students saw the experience as a pleasant one.
- 62% of the students believe the approach had a strongly positive educational impact, 33% believe the impact was just positive, and only 5% believe that the impact was negative with none having a strong negative opinion. As the ultimate goal of the approach is to enable an effective educational paradigm, this 5%, however small, must be further investigated.
- 91% of the students saw the experience as a highly creative one and 5% as just creative. This is a very encouraging result as it clearly indicates that all students have experienced the increased creativity potential the approach – and Virtual Reality, as a consequence – represents.
- 91% of the students, of which 41% have a strong favourable opinion, would like to have the option to carry out assignments for other course modules (not necessarily related to Virtual Reality) based on similar approaches.

Regarding two crucial aspects of the whole endeavour, namely, the elements of cooperation and inevitable (and hoped-for) well-meant competition due to students being constantly able to monitor the work of others as it took place:

- 47% of the students are strongly in favour of the collaborative scheme, while 31% are just in favour. However, 22% would have rather worked alone. It must be noted that this is not about teamwork: the formation of teams was optional as students were by all means allowed to work individually; rather, it reflects that a non-negligible 20% of the students felt uncomfortable with having to share the same work space with, and being under constant surveillance by, their colleagues.
- Along the above lines, 57% had absolutely no problems due to the fact that other users could navigate freely to and in their allocated areas. 28% were simply OK with it while an again non-negligible 15% were not, with a 5% having a strong negative opinion.
- 66% of the students declared that their observation of their colleagues' work made them revisit their original planning and and adjust their design goals and methods to at least some degree, while an additional 17% state that they completely changed direction for similar reasons. 18% were affected only a very little or not at all. This is a most remarkable result as it indicates that the inherent capacity of the approach to enable competition has affected a good 83% of all students who participated in the survey in spite of the fact that reconsideration of one's design goals and practices is always a decisive, risky, never-effortless option.

The survey also made it possible to draw useful conclusions on the aspects of concurrent online accessibility and the remote-work model:

- The online, concurrent access model is favoured by a marginal majority of 58%. The other 42% would have rather worked on a standalone server reserved for them or their team. We mean to investigate the nature of this result thoroughly. We believe that it has much to do with a variety of technical obstacles that arose during the term, which had an undoubtedly negative impact on the students' ability to access the virtual world and has, perhaps, lowered their confidence in the general practice of online access to a shared virtual world (which they are completely unable to manage in contrast with a fully-manageable local server).
- However, provided that the virtual world was available, the concurrent online access model had minimal negative impact (if any) to most students: A total of 83% answered that the

presence of multiple users in the virtual world did not hinder their ability to work without problems related to service availability, response latency, etc.

It must also be noted that, although students were largely responsible for resolving land- and building-related "disputes", unauthorised content replication issues, etc., there were certain occasions on which we had to intervene, as we believe any instructor coordinating a similar effort will have to do. For instance, on a few occasions, we had to deactivate pieces of scripting code that disregarded good programming practices (regardless of the relevant discussions during class) and, as a result, drained the virtual world server's resources. However, those occasions were rare and created no significant problems of any kind.

5 CONCLUSIONS AND FUTURE WORK

In this paper, we present our current efforts towards a novel, problem-based learning paradigm for academic-level education on topics related to Virtual Reality as well as our results from the application of the paradigm on a Virtual Reality-related BSc course module during the academic year of 2011-2012. Our approach aimed at the collaborative design of a shared, remotely- and concurrently-accessible virtual world and relies exclusively on free software tools based on the Second Life virtual environment, namely, the Open Simulator platform and Second Life-compatible viewers.

Based on our own subjective impressions of how students welcomed the novel approach as well as their collective opinions about it as expressed through a questionnaire-based survey, and in spite of numerous technical issues both we and the students faced during the term, we feel that the endeavour was overall successful and beneficial on different levels for most, if not all, of the students who participated. For this reason, we will maintain our commitment to the underlying paradigm while working to further augment its educational impact and systematize its applicability.

More specifically, we plan to adopt a similar approach for two course modules (one BSc-level and one MSc-level) during the academic year of 2012-2013. This will give us the opportunity to obtain richer evaluation data, investigate a potential correlation between different academic backgrounds and the paradigm's suitability, as well as enhance the assessment process by adopting more specific and robust evaluation criteria. We also aim to enhance the element of cooperation by assigning one region to each module adjacent to the region which was used in the case of the 2011-2012 BSc-level course module presented in this paper, so that all students are able to observe, and draw inspiration by, the work of other students. In addition, we aim to further expand the application of the paradigm by seeking cross-departmental and cross-institutional co-operations. In conclusion, we have already taken measures to prevent technical problems aiming to ensure that the proposed paradigm's potential educational benefits will not be hindered by inadequate infrastructure and lack of resources.

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“Artificial Communication“

Can Computer Generated Speech Improve Communication of Autistic Children?

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Keywords: Natural Language Processing, Autistic, Autonomous Toy, Robot, Children.

Abstract: Autistic children are often motivated in their communication behaviour by pets or toys. Our aim is to investigate, how communication with “intelligent“ systems affects the interaction of children with untypical development. Natural language processing is intended to be used in toys to talk to children. This challenging Háblame-project (as part of the EU-funded Gaviota project) is just starting. We will discuss verification of its premises and its potentials, and outline the technical solution.

1 INTRODUCTION

It is a well established fact that autistic children often are motivated in their communication behaviour by pets or toys, e.g. in the IROMEC project (Ferari, Robins, Dautenhahn, 2009), (IROMEC, 2013). We found analogous results in a group of disabled persons who were motivated by technical systems to move or dance. (Pina, 2011).

Within the Gaviota Project (Gaviota, 2012), we want to investigate, how communication with “intelligent“ systems affects the interaction of children with untypical development.

2 PREVIOUS WORK

2.1 The Beginning: Eliza

As early as 1966 Weizenbaum (Weizenbaum, 1966) implemented an interaction technique which was introduced by Carl Rogers (client centered psychotherapy, (Rogers, 1951)). This therapy mainly paraphrases the statement of the client. The Eliza implementation used to react to a limited number of key words (family, mother, ...) to continue a dialog. Eliza had no (deep) knowledge about domains - not even shallow reasoning, rather a tricky substitution of strings. Modern versions of Eliza can be tested on several websites, e.g. (ELIZA, 2013).

2.2 Robots in Autism Therapy

So far robots in autism therapy have been used to enhance the abilities of children to play, using robots as a toy, which means they playfully interact with robots.

The robot’s simple face can be changed to show feelings of sadness or happiness by different shapes of the mouth (IROMEC, 2013).

These robots (which are just special computer screens in a first step) execute pre-defined scenarios of interaction, and are controlled by humans.

So far results have shown that more children are responding to those robots compared to the children that do not respond.

2.3 State-of-the-Art Dialog Systems

State of the art dialog systems (e.g. the original Deutsche Bahn system giving information about train time tables, or the extended system by Philips) are able to guide people who call a hotline and execute standardized business processes (delivering account data, changing address data, etc.). Those systems work well, but within an extremely limited domain.

2.4 Natural Language Processing (NLP)

A spectacular demonstration of natural language processing was given by IBM's artificial intelligence computer system Watson in 2011, when it competed on the quiz show Jeopardy! against former human winners of that popular US television show (JEOPARDY, 2011).

IBM used the Apache UIMA framework, a standard widely used in artificial intelligence (UIMA, 2013). UIMA means "Unstructured Information Management Architecture".

UIMA can be viewed from different points of view:

1) architectural: UIMA represents a pipeline of subsequent components which follow each other in an analytical process, to build up structured knowledge out of unstructured data. UIMA primarily does not standardize the components, but the interfaces between components.
   "... for example "language identification" => "language specific segmentation" => "sentence boundary detection" => "entity detection (person/place names etc.)". Each component implements interfaces defined by the framework and provides self-describing metadata via XML descriptor files. The framework manages these components and the data flow between them. Components are written in Java or C++; the data that flows between components is designed for efficient mapping between these languages". (UIMA, 2013).
2) UIMA supports the software architect by a set of design patterns.
3) UIMA contains two different ways of representing data: a fast in-memory representation of annotations (high-performance analytics) and an XML representation (integration with remote web services).

The source code for a reference implementation of this framework is available on the website of the Apache Software Foundation.

Systems that are used in medical environments to analyze clinical notes serve as examples.

2.5 Natural Language Processing in Pedagogics

So far there are no reasoning systems with knowledge about the domain of how to behave properly in a pedagogical way.

3 HYPOTHESIS: NATURAL LANGUAGE SPEAKING MIGHT BE HELPFUL

The IROMEC project demonstrated that weekly sessions with a robot with rather simple abilities to move and show emotions by standardized facial expressions are helpful to enable/empower children to play more naturally than without those sessions (Ferari, Robins, Dautenhahn, 2009). So we concluded that it is worth trying to build a robot, which is talking autonomously with a child in rather simple and standardized words and sentences. We decided to start a subproject Háblame („talk to me“) to investigate the chances and problems of building such a robot as part of the EU-funded Gaviota project.

4 THE PROJECT „HÁBLAME“

4.1 Verification of the Hypothesis

Before we start the core project, we have to verify our hypothesis: we have to show that autistic children positively react to toys which talk to them. We will build a simple prototype without NLP-functions. Speech will be produced by a hidden person via microphone and suitably placed speakers.

4.2 Concept of a Dialog System

Within the project, we first had to / have to get experience with natural language processing. When we studied basic concepts of NLP (Figure 1), we decided to put stress on syntax parsing and semantic parsing.

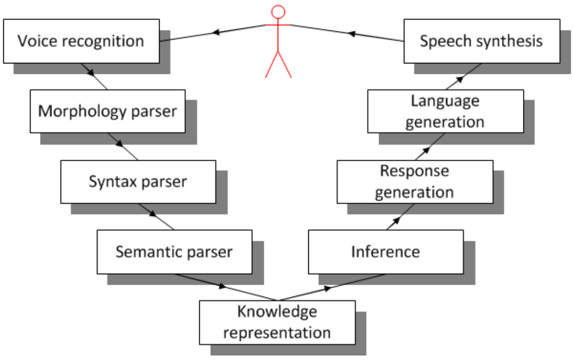

Figure 1: Concept of a dialog system (Schneider, 2012).

4.3 Parsing Syntax of Natural Languages

First a prototype parser – based on a grammar developed by Roland Hausser (Hausser, 2000) – was implemented, which can analyze simple sentences entered in English. The parser processes the sentence entered, splits it into words and compares them to a lexicon, specified in an external text file.

It tries to re-combine the sentence word by word, taking account of the *valences*, also specified in the lexicon. If the sentence can be re-combined correctly and all free valences are filled, the parsing process was successful. Otherwise the sentence is grammatically incorrect (or the parser could not deal with it).

4.3.1 Parser Prototype and Valences

The parser works with valences of words, e.g.:

- <u>*to sleep*</u> has 1 nominative valence →
  Peter sleeps.
- <u>*to give*</u> has 1 nominative valence (abbreviated Nx), 1 dative valence (Dx) and 1 accusative valence (Ax) →
  Peter gives Mary books.
- All valences (mostly opened by verbs) have to be filled (mostly by nouns). Otherwise the sentence is not correct, e.g.: *Peter gives Mary.* → accusative noun is missing.

One can think of valences as slots, which have to be filled with proper words.

4.3.2 Processing Valences

Valid words, their valences and their function (V = verb, PN = plural noun, etc.) have to be specified in an external lexicon, e.g.:

- *sleeps NS3x V*
  (S3: use only with 3rd person singular)
- *give N-S3x Dx Ax V*
  (-S3: use NOT with 3rd person singular)
- *books PN*

Words currently have to be entered in the lexicon with all flection forms used, e.g.:

- *give N-S3x Dx Ax V*
- *gives NS3x Dx Ax V*
- *gave Nx Dx Ax V*

The parser takes the first word of the sentence and combines it with the following word to a more complex starting sequence using predefined rules, e.g.:

- Noun phrase followed by a verb with corresponding valence → erase the valence satisfied:
  Peter (SNP) sleeps (NS3x V). →
  Peter sleeps (V).
- Article followed by adjective → do not change any valences:
  The (SNx SNP) beautiful (ADJ) … →
  The beautiful (SNx SNP) …

This combining procedure is repeated bottom-up until the end of the sentence is reached (Figure 2).

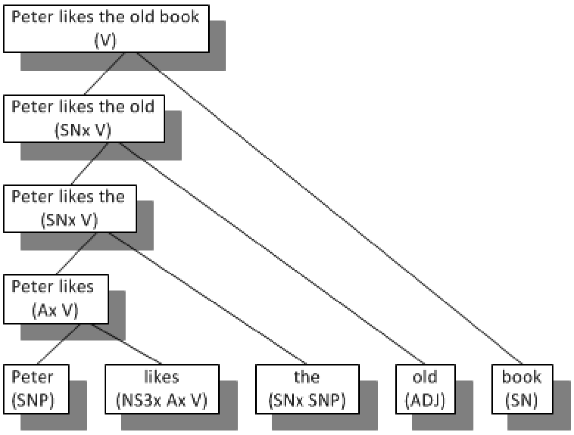

Figure 2: Bottom-up processing of valences (Schneider, 2012), cf. (Hausser, 2000).

Examples of sentences, the prototype of the parser can deal with:

- *The beautiful girl reads an old book.*
- *Does Peter sleep?*
- *Mary has bought a new car.*

Examples of sentences, the prototype currently cannot deal with:

- *Beautiful girls like Peter.*
- *Reading books gives Peter pleasure.*
- *Peter, who is 20 years old, sleeps.*

4.4 Processing of Semantics of Natural Languages – Analyzing Semantics

Analyzing the semantics of natural language, we first define our prerequisites and our goals:

- Prerequisites:
  Oral utterances (of children) are transcribed by a supervisor and fed into the system. The sentences are analyzed one by one, and the results of the analysis should be stored in a semantic network
- Goals:
  - Exploring the linguistic techniques for semantic analysis.
  - Determining the technical and linguistic preconditions.

- Evaluate which software components and libraries may be used to accomplish this task.
- Evaluate which libraries can be used to access a semantic network, and how to create the necessary ontologies.
- Building a software prototype, which integrates all necessary components.

Basically, there are two approaches towards linguistic analyzing:

The „**formal**“ approach:

Every sentence represents a logical statement („Proposition“), and we have to translate every sentence into meta-language. Those languages are called „Meaning Representation Languages“ (MRL) and are often based on first order logic or the lambda calculus.

The „cognitive“ approach:

One can‘t determine the exact meaning of a sentence by the sentence itself. A straightforward translation of language into a logical representation is therefore impossible.

In the process of understanding there is a lot of background knowledge involved.

This knowledge may be specific to a single person or a group of persons (e.g. cultural or personal background).

4.4.1 Adoption in Computational Linguistics

The *formal* approach is well explored and adopted in Computational Linguistics.

Its main advantages are easy integration with code and other logical structures like semantic networks. The disadvantage is that it is not language agnostic and very narrow in scope (one has to define logical expressions for every meaning of a sentence).

The cognitive approach was investigated mainly by adopting Fillmore‘s work on frame semantics, which he developed back in the 1970s (Fillmore, 2006). His idea was that the meaning of a sentence can be described by a so-called frame or a combination of those. A frame is consisting of:

- A description which outlines the meaning of the frame
- A number of frame elements (FE) that describe possible roles or agents
- Relations to other frames, including specialization, part-of or temporal relations
- A number of language specific lexical units, i.e. words or groups of words, which may evoke that frame.

The main advantage of the cognitive, frame-based approach is, that frames are language agnostic, so only the lexical units that may evoke a frame have to be defined per language. Every frame is a formal representation of meaning, so there is no reason to build an own meta-language. The scope is very broad and not limited to a specific application.

4.4.2 Software Tools for FrameNet based Analysis (Cognitive Approach)

The FrameNet database consists of a large set of XML files (FrameNet, 2012).

Frame semantic parsers relying on FrameNet already exist, both systems use a probabilistic approach:

- SHALMANESER (English, German) is a project at Saarland University, Saarbrücken, Germany, and
- SEMAFOR (English) is a project at Carnegie Mellon University, Pittsburgh, USA.

4.4.3 Preprocessing of Sentences (Cognitive Approach)

In a first step we preprocess the sentences to be analyzed:

- Tokenizing: we split sentences into words (Apache NLP Tools),
- POS-Tagging: we determine the part of speech of each token (Apache NLP Tools),
- Syntactic parsing: Determining the grammatical components of each sentence (Maximum Spanning Tree Parser, Pennsylvania State University),
- Named Entity Recognition: Check if one or more tokens represent a proper noun, a number, a date, etc. (Apache NLP Tools),
- Frame identifications: Find the frames that match the given sentence (Semafor, Carnegie Mellon University, Pittsburgh, USA).

5 RESULTS

So far there are only results, as far as NLP is concerned:

- The pre-trained classifiers for both SHALMANESER and SEMAFOR did not yield good results with our test data.
  - SHALMANESER is hard to integrate with other tools.
  - There are plenty of java-based tools to preprocess the data and extract features that can be used with probabilistic models. Fur-

thermore, many of these tools can be integrated with the Apache UIMA platform.
- A modular, client/server based approach proved to be necessary for the project.
- A fairly large corpus of transcribed child language is nearly impossible to obtain.
- Although there are FrameNet data sets for a couple of languages (Spanish, German, Chinese, etc.), their number of frames and lexical units is presumably too small to use for semantic parsing.

6 CONCLUSIONS

First we have to verify that autistic children react to the prototype system in the manner expected.

If this is done successfully, there is much work left to be done on the NLP side. We will not do further research on using FrameNet with the Semafor parser however, nor use *database semantics* (another approach, which is not covered in this report).

We will intensify research on custom probabilistic models with the following steps:

1. set up Apache UIMA since the NLP tools are easy to integrate,
2. obtain a domain specific corpus,
3. split that corpus into a training and a test part,
4. annotate the corpus with semantic class labels,
5. select domain specific and situational features,
6. incorporate the features generated by the preprocessing tools (i.e. taggers, parsers, etc.),
7. train a probabilistic model, possibly by using the MaxEnt library of the Apache NLP tools,
8. evaluate the performance with different feature sets.

6.1 Necessary Data

We need corpora about children's language domains, and we have to decide, which age level, and which speech domains. If no corpus is available, we have to develop one. Those corpora should be in English language to develop and stabilize the system. Later iterations may incorporate German and Spanish language.

6.2 Further Steps

We will set up an experimental environment, based on the work already done, gather experience and knowledge on analyzing/parsing natural language. Then we have to acquire or produce corpora covering our domain of interest (child language). Furthermore we have to work on creating natural sentences as part of a dialog.

ACKNOWLEDGEMENTS

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SOCIAL CONTEXT AND LEARNING ENVIRONMENTS

FULL PAPERS

Cultural Differences in e-Learning Behaviour and Overall Assessment

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Keywords: e-Learning, Cultural Adaptation, Assessment Criteria, Peer Assessment, Course Evaluation.

Abstract: The article analyses the influence of culture on e-learning behaviour in form of LMS tool usage, assessment of peers, and post-graduate student's grades. E-learning behaviour in this research relates to tool usage such as email, discussion board, number of sessions, time spent etc. The analysis suggests adapting e-learning to participants based on their culture as well as making students aware that there may be a cultural bias in assessing their peer's contributions. Especially European students rate their Asian peers more than 10% lower than their European ones although the overall GPA does not differ. Europeans do better in group assignments than Asian students especially South Asians who perform better at individual assignments in a culturally diverse setting. The qualitative findings provide additional evidence that cultural features do have an impact on e-learning behaviours.

1 INTRODUCTION

Hofstede's (1991, p. 89) definition of culture as "the collective programming of the mind that distinguishes one group or category of people from another" and more recently, the GLOBE project defining culture as "shared motives, values, beliefs, identities, and interpretations or meanings of significant events that result from common experiences of members of collectives that are transmitted across generations" (House et al., 2004, p. 230) suggest that experiences and shared values constitute a cultural group. Researchers generally agree that variations between groups can exist on multiple dimensions (cognitions, behaviours, and values). However, cross-cultural research is mainly focused on cultural values. In contrast, this paper focuses on behaviours in the context of e-learning. In our paper we investigated the influence of cultural context on online learning behaviour of executive MBA students at an online university based in Singapore. Seven post-graduate elective business simulation courses with a total of 206 students from 2006 to 2010 were analysed. The average age of students was 38 years with predominantly engineering background who want to pursue an MBA to further increase their management competence. Although based in Singapore the online university attracts a large number of South Asian (e.g. India, Indonesia) as well East Asians (e.g Japan, China, Taiwan) and Europeans. The seven selected business simulation courses were taught by the same tutor, using the same software (Markstrat from Insead), time span of 12 weeks each, and same weight for assignments. A mix of nationalities was encouraged and sometimes directed by the tutor.

2 RESEARCH OBJECTIVES AND THEORETICAL FRAMEWORK

For cross-cultural theory of E-learning at the national level the major issue is measurement. There are five major perspectives. The first is Hofstede (1991) which has been the most widely used and criticised (Hofstede et al., 2010). Related to this perspective is Project Globe (House et al., 2004) which followed a different approach in methodology and sampling but with similar categories. Trompenaars & Hampden-Turner (2004) represents a third approach which is based on executive participants in management development programs answering questions about value dilemmas. The fourth approach is the Schwartz Value Survey (1992) which covers many countries based on respondents who are students and teachers. Finally, Triandis (2001) uses an individualism-collectivism spectrum. Each approach has advantages and disadvantages. Typically, an approach is used as a standard measurement of a particular culture. A more qualitative approach is the distinction between high and low context cultures. According to Hall (1976) East-Asia (EA, e.g. Japan) would represent a high context culture whereas Europe (EU) a rather low-context culture with India somewhere in between. Higher context cultures generally have a stronger sense of group orientation, seniority, unspoken rules, and tradition. In Hofstede's (1991) and Trompenaars (2004) classification systems, South-Asia (SA) would be somewhere between EA and EU.

Swierczek and Bechter (2008) amalgamated and applied these approaches to e-learning, see Table 1, demonstrating that High Context cultures show a more a 'wait and see' reactive mode. Low Context learner cultures show higher volume, less depth and can be considered as more provocative and innovative.

Table 1: Features of High vs. Low e-learning cultures.

High Context (East-Asian)	Low Context (European)
Introvert	Extrovert
Modest	Superior
Reactive	Active
Reflective	Thinks outloud
Natural	Exaggerated
Reads First	Posts First
Data Focused	Monologue Dominant
High Frequency	High Involvement
Group oriented	Individual Achievement oriented
Team Harmony	
Deduction	Critical Peer evaluation
Share knowledge within group	Induction
	Share knowledge openly
Tutor as Leader	Tutor as Facilitator

The purpose of the study is to analyse culture related e–learning behaviour and its outcome.

The research questions are:

1. What is the relationship between a culture like South-Asia (SA), Europe (EU) or East-Asia (EA) on e-learning behaviours?
2. Does culture influence e-learning?
3. Is it possible to design an e-learning approach which is compatible with different cultures?

The objectives of this research:

1. To assess e-learning behaviours of post-graduate students.
2. To determine the influence of cultural values on e–learning behaviours.
3. To identify the impact of culture on e-learning activities.
4. To compare peer assessments of participants working together with student colleagues from different cultures.
5. To propose a multi-culturally compatible approach to e-learning design.

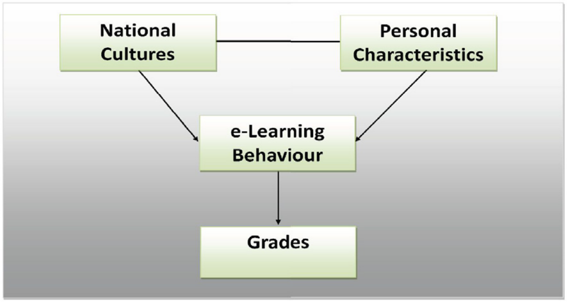

Figure 1: Research Framework.

The paper is structured in the way that overall assessments for students and tutor will be analysed in a first step. In a second step student online behaviour (input) and grades (output) split by cultural group will be compared. Included in the grade analysis is a comparison of peer assessment grades followed by relative success of cultural regions in group vs. individual assignments. In line with a mixed method approach (Creswell, 2009) some quotes from online discussions are provided. To test the hypothesis that there are cultural differences a second, purely quantitative, approach was used by grouping of students (clustering) along major e-learning behavioural dimensions (factors). Finally, results of both approaches were compared and recommendations given.

3 FINDINGS

3.1 Overall Assessment

The overall assessment grade (GPA) consisted of seven components. Discussion Board (DB) contributions accounting for 30%, two case studies (GA) 30%, final project (FP) 15% and final exam 25%. The case studies did not differ in complexity but were replaced by more current ones every two years. Case studies and final project (summary of the key learning points of the simulation game) were group assignments with team sizes ranging from five to seven participants.

Table 2: Overall assessment and its components.

	N	Mean	Std. Deviation
GA_1	205	82.93	14.525
GA_2	206	83.04	14.581
FP	206	82.71	12.708
DB_1	206	84.76	11.565
DB_2	206	84.41	12.942
DB_3	206	81.85	14.089
Final Exam	206	77.13	13.596
GPA	206	81.54	10.085
Valid N	205		

Grades ranged from 0 to 100, average see Table 2. Final exam score is below other assessment criteria which could be related to exam phobia or time pressure or tutor related by not advising students what was expected. The grades for online participation on the Discussion Board (DB) declined slightly toward the end of the course: DB_1: week 1-4; DB_2: week 5-8; DB_3 week 9-12. The two group assignments (GA_1 & GA_2) took place in the first eight weeks whereas the final project (FP) was due at the end of the course, shortly before the final exam. The GPA is relatively high which may be due to the fact that this was an elective course. Whereas individual assignments were solely graded by the tutor, the group assignments had a peer assessment component whereby each student was asked to rate team colleague's contributions on a scale 1-5.

Students were asked to evaluate subject content (25 questions) and tutor (22 questions) upon completion of the course. Table 3 shows the averages of five selected questions on a scale 1-5:

S_A4. The various learning tools were used effectively (e.g. discussion boards, self-assessment exercises, instant messenger, webinar).

S_B7. The case studies and final project selected for this subject were useful for my learning needs.

S_C3. The ratio of individual to team assignments was appropriate.

S_E1. Overall, how would you rate the quality of your learning in this subject?

T_D1: Overall, how would you rate the performance of the professor in this subject?

The four subject related (S_) items as well as overall tutor satisfaction (T_) was high. For obvious reasons it is not possible to make the link between individual evaluation and a particular student; otherwise the tutor may penalise that student in courses to come (Table 3).

Table 3: Course evaluation by students.

	N	Mean	Std. Deviation
S_A4	206	4.30	0.881
S_B7	206	4.47	0.689
S_C3	206	4.36	0.751
S_E1	206	4.46	0.645
T_D1	206	4.51	0.703
Valid N	206		

There is a significant high correlation between perceived quality of learning and tutor performance which indicates that a student who 'likes' the tutor may also like the subject and vice versa, see Table 4.

Table 4: Correlation between Subject and Tutor satisfaction.

		S_E1	T_D1
S_E1	Pearson Correlation	1.000	.851**
	Sig. (2-tailed)		.000
	N	206.000	206
T_D1	Pearson Correlation	.851**	1.000
	Sig. (2-tailed)	.000	
	N	206	206.000

**. Correlation is significant at the 0.01 level (2-tailed).

This should be taken into consideration when assessing a tutor's performance based on students' evaluations as many universities nowadays do. For example, the Singaporean university in question will not renew contracts if the overall evaluation falls short of 4.2 which may be caused by teaching a less exiting subject or the pedagogical performance of the tutor. As above evaluation shows, students were generally satisfied with subject and tutor which may be a result of their active learning behaviour.

3.2 Learning Behaviour

The business simulation course consisted of 160 SCORM modules. Blackboard served as LMS with readily available statistics such as:

- Number of session during the 12 week course
- Total Time spent
- Number of eMails read
- Number of eMails sent
- Number of DB posts read
- Number of DB replies posted
- Number of times the (LMS internal) organizer with upcoming events/deadline was viewed
- Peer assessment scores and Grades

Most of the behavioural input factors correlate positively with the GPA. Students that engage via email or discussion board are more successful. The

Table 5: Correlations: Input vs. Overall Assessment Grade (GPA).

Pearson Correlation	Sessions	Total Time	Mail_Read	Mail_Sent	DB_Read	DB_Posted	SCORM	Organiser	GPA
ssions		.467**	.209**	.312**	.479**	.453**	.631**	.146*	.397**
Total Time	.467**		.111	.144*	.226**	.386**	.389**	-.109	.330**
Mail_Read	.209**	.111		.660**	.055	-.022	.187**	.056	.171*
Mail_Sent	.312**	.144*	.660**		.165*	.131	.166*	-.001	.224**
DB_Read	.479**	.226**	.055	.165*		.294**	.161*	.062	.178*
DB_Posted	.453**	.386**	-.022	.131	.294**		.138*	.026	.379**
SCORM	.631**	.389**	.187**	.166*	.161*	.138*		.194**	.274**
Organiser	.146*	-.109	.056	-.001	.062	.026	.194**		-.042
GPA	.397**	.330**	.171*	.224**	.178*	.379**	.274**	-.042	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

only tool that did not contribute to the success was the organizer; viewing deadlines doesn't seem to constitute a high performing student. On the contrary, it correlates slightly (but non-significantly) negatively, see Table 5. Organizer is a typical 'uncertainty avoidance' parameter.

Table 5 suggests that e-learning behaviour component correlate i.e. a student spending a lot of time online is also more active and gets a better grade than not so active ones. There is a high correlation between mail read and sent as well as DB posted and read which may indicate a preference for a specific communication tool.

3.2.1 Cultural Differences

At first sight there seem to be no significant differences between East-Asian (EA) students, Europeans (EU) and South-Asians (SA). Numbers of sessions as well as average grades (GPA) are similar, see Table 6, and do not differ significantly.

Table 6: Overall Sessions and GPA.

Nationality		N	Mean	Std. Deviation
EA	Sessions	75	147.65	77.509
	GPA	75	81.35	10.732
EU	Sessions	32	144.41	93.429
	GPA	32	81.70	11.541
SA	Sessions	99	142.53	78.528
	GPA	99	81.64	9.143

Given that a course lasts for 12 weeks it can be concluded that on average a student logs in around 1 ½ times per day; more realistically, once per working day and 5 times over the weekend because they were executive students.

Despite an overall similar picture, we see behavioural differences when comparing cultural regions in more detail. Differences between EA (East-Asians) and SA (South-Asians) and EU (Europeans) that were significant at 0.05 levels are highlighted in *italics*, see Table 7.

Table 7: e-Learning behaviour by culture.

	Nationality	N	Mean	Sig.
Mail_ Read	EA	75	48.8	
	SA	99	*50.47*	Yes, vs. EA
	EU	32	*53.16*	Yes, vs. EA
Mail_ Sent	EA	74	6.18	no
	SA	99	7.36	no
	EU	32	10.53	no
DB_ Read	EA	75	4707	
	SA	99	*7264*	Yes, vs. EA
	EU	32	*8240*	Yes, vs. EA
DB_ Posted	EA	75	101	
	SA	99	102	
	EU	32	*157*	Yes, vs. EA & SA
SCORM	EA	75	204	no
	SA	99	191	no
	EU	32	181	no
Organiser	EA	75	7.21	no
	SA	99	7.51	no
	EU	32	8.19	no

SA and EU read more mails and more DB posts. Given the fact that each student posts around 100 replies on the DB and on average there are 40 students per class, we can expect around 4000 DB postings per course. This means that EA view a post more or less once whereas their SA counterparts view some post at least twice. EU were the most active group in DB postings which didn't translate into a better DB grade, see Table 8.

Table 8: Grade Component Differences by Culture.

	Nationality	N	Mean	Sig.
GA_1	EA	75	82.79	
	SA	98	81.49	
	EU	32	*87.66*	Yes, vs. EA & SA
GA_2	EA	75	82.55	
	SA	99	82.24	
	EU	32	*86.66*	Yes, vs. EA & SA
FP	EA	75	81.41	No
	SA	99	83.48	No
	EU	32	83.38	No
DB_1	EA	75	86.39	No
	SA	99	84.10	No
	EU	32	83.00	No
DB_2	EA	75	83.15	No
	SA	99	84.68	No
	EU	32	86.56	No
DB_3	EA	75	81.67	Yes, vs. EU
	SA	99	83.63	Yes, vs. EU
	EU	32	76.81	
Exam	EA	75	76.64	No
	SA	99	77.99	No
	EU	32	75.59	No

An explanation could be that EA's and SA's postings show more substance and EU are more frequent but shallower. Whereas emails do not form part of the grade, DB contributions do. An extensive list with evaluation criteria was provided prior to the course to eliminate a subjective judgement as much as possible.

After analysing the behavioural input (Table7), what tools were used, we looked at the grade in more detail (Table 8). We have seen in Table 6 that the overall grade did not differ significantly between EA, EU, and SA. Looking at the grade components/criteria, however, there are three differences, see Table 8.

EU students seem to take it relatively easier with DB contributions toward the end of the term (DB_3: week 9-12) whereas their Asian counterparts maintain their high level of activity throughout the course.

3.2.2 Peer Assessment

Peer assessment is essential part of collaborative learning.

Table 9: Peer Assessment.

Assessment Criteria	Name	Team members (initials)				
		GJ	FC	BW	JA	MS
Collection of data	Goh J	5	5	5	3	3
	Foo C	3	3	4	4	4
	Bob W	3	3	4	5	4
	Joy A	4	4	5	5	5
	Muthu S	4	4	5	5	5
Data analysis	Goh J	5	4	5	4	3
	Foo C	3	2	3	4	2
	Bob W	3	3	5	5	4
	Joy A	4	4	5	5	5
	Muthu S	4	4	5	5	5
Co-ordination and writing of submission	Goh J	5	5	4	3	3
	Foo C	2	4	5	2	4
	Bob W	3	3	5	4	4
	Joy A	4	4	5	5	5
	Muthu S	4	4	5	5	5
Overall quality of input (creative ideas, insights)	Goh J	5	4	4	3	3
	Foo C	3	3	4	5	4
	Bob W	3	3	4	5	4
	Joy A	4	4	5	5	5
	Muthu S	4	4	5	5	5
Overall contribution to the efficient functioning of team	Goh J	5	5	5	3	3
	Foo C	3	2	4	5	4
	Bob W	4	4	5	5	4
	Joy A	4	4	5	5	5
	Muthu S	4	4	5	5	5

After each group assignment including the final project students were asked to rate anonymously their peers on 5 categories, see above Table 9, from 1-5. The peer assessment accounts for around 25% of the group assignment grade. Because we hypothesized that groups from the same culture will rank their peers higher than from other cultures we calculated three different peer scores.

In Table 9 we see peer scores of 5 students:

- Goh J: EA
- Foo C: EA
- Bob W: EU
- Joy A: SA
- Muthu S: SA

To calculate the Peer_other (culture) score for Goh (the average score s/he gave to peers, not the one s/he received) we will not consider Foo because s/he is from the same culture, instead only the two SA and one EU team member will be considered. For Peer_own only Foo would qualify. Peer_score gives the average score this person gave to all team members.

We can see that EU and SA give similar scores between 4.1 and 4.3 to students sharing the same cultural background but drop if they evaluate students from another cultures; especially the EU gap is significantly high (4.289 vs. 3.747).

Table 10: Peer Score.

	Nationality	N	Mean	Std. Deviation
Peer_score	EU	32	4.018	0.571
	SA	99	4.006	0.522
	EA	75	4.040	0.540
Peer_own	EU	32	*4.289*	0.454
	SA	99	4.113	0.566
	EA	75	4.230	0.560
Peer_other	EU	32	*3.747*	10.328
	SA	99	3.899	0.517
	EA	75	3.860	0.540

The results confirm that there is a cultural bias in peer assessment which may be down to the fact that one relates more easily to the own culture. A similar pattern can be found on DB where students tend to reply to postings made by same culture students more frequently than others. One could argue that it is difficult, for example, for an Indian to relate to Haier as for a Chinese to Amul and more engaging the other way round.

3.2.3 Group vs. Individual Assignments

Looking at the grades, SA performed 1.59% better than average in the final project (FP) and EA 1.25% better in the GAs. A minus sign indicates a tendency to the left (GA) and a plus sign to the right (FP), see Table 11. EA preferred group assignments, whereas SA preferred Individual assignments. Both, GA and FP are group assignments but at a different level. GA covered case studies whereas the FP was far more team oriented in form of a simulation game. Quite often students split case study tasks getting close to becoming an individual assignment.

GroupvsIndi measured the different performance between team work (GA, FP) and truly individual assignments (3 DBs, final exam). Only SA performed better at individual assignments. Pramila (2011) came to similar conclusions that Indian students are more individualistic and less group-oriented which would bring them closer to low context cultures.

Table 11: Group vs. Individual Assignment.

	Nationality	N	Mean	Std. Deviation
GAvsFP	SA	99	1.586	11.466
	EA	75	-1.253	11.517
	EU	32	3.000	14.870
GroupvsIndi	SA	99	0.210	5.536
	EA	75	-0.290	7.657
	EU	32	-5.400	16.440

Surprisingly, Europeans tend toward group assignments. The values in above tables do not represent perceptions or likeability, instead they stand for the relative success, expressed as grade points (range from 0 to 100), between various forms of formal assessments. One reason could be that Europeans take the initiative and volunteer to become team leaders. A study by Klein (2012) has shown that successful teams have a strong leadership and delegate tasks; similar to this study a computer game/simulation was analysed. Sometimes EU students were frustrated by the slow pace of reaching a (for high context cultures typical) consensus and took things in their own hands (Table 12).

Table 12: Sample DB Postings.

EU:	Lets get started with the activity, before we run out of time.
EA_1:	From a suggestion made by Prof, I have purchased all the market research studies.
EA_2	Thanks! Please go ahead.
SA_1:	My relocation got me really tied up. Moved from Egypt to UAE after 9 years. Tough call. Ready to contribute and will from now.
EU:	Team, Any update... we have to make decision by midnight today for next round.
EA_2:	I doubt anyone has the time to do a thorough analysis of the results from period 1. I have made some simple observations:…
SA_2:	Guys, We missed tdy's deadline to upload next decision on Markstrat. Need to ensure that we do our best fr next round..
EU:	The way we have been doing this is quite disorganized and without directions…
SA_1:	Logging in.
EU:	Hi team, I have initiated 2 R&D projects: …

Table 12 demonstrates that the EU student shows leadership whereas EA_1 tries to avoid uncertainty (another feature of high context cultures) and gets reconfirmed by EA_2. Both EAs including the one SA do not move things forward; they rather take a 'wait and see' attitude. Finding themselves in the diver seat may challenge EU students resulting in better grades in group than individual assignments. Language proficiency could be another reason.

3.2.4 Grouping across Cultures

We have seen that culture has an impact on e-learning behaviour and learning success. However, even within a culture differences can exist; a person from one culture can be closer to another culture than its own. To analyse the proximity of students in the sample a cluster analysis was conducted.

To reduce the number of dimensions a factor analysis was applied beforehand, resulting in 3 major dimensions, see Table 13.

Table 13: Rotated Component Matrix.

	Factor		
	Time	eMail	Organizer
Sessions	*.798*	.231	.341
Total Time	*.747*	.093	-.133
DB_Posted	*.716*	-.066	-.096
DB_Read	.590	.048	.099
Mail_Read	-.005	*.915*	.073
Mail_Sent	.160	*.887*	-.021
Organiser	-.086	-.034	*.894*
SCORM	.523	.188	.527
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			

Factor 1 is the most important dimension and can explain 29.5%, Factor 2 21.6% and Factor 3 14% of variance. Along these 3 dimensions a subsequent clustering of students was conducted. Whereas Factor 1 and 2 correlate positively with the GPA, Factor 3 does not, see Table 14.

Table 14: Correlations between Factors and GPA.

		GPA
REGR factor score 1	Pearson Correlation	.440**
REGR factor score 2	Pearson Correlation	.176*
REGR factor score 3	Pearson Correlation	-0.004
**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).		

A cluster analysis based on the three factors resulted in 4 distinct groups (Table 15).

Table 15: Cluster by Nationality.

Cluster	EA		EU		SA	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
1 (SA)	1	1.4%	0	.0%	18	18.2%
2 (SA)	0	.0%	0	.0%	81	81.8%
3 (EU)	0	.0%	32	100.0%	0	.0%
4 (EA)	73	98.6%	0	.0%	0	.0%
Combined	74	100.0%	32	100.0%	99	100.0%

Cluster 1 is dominated by SA, cluster 2 also by SA, cluster 3 by EU and cluster 4 by EA. This confirms that there are cultural differences in e-learning behaviour; Cluster centroids, see Table 16.

Table 16: Centroids.

Cluster	REGR factor score 1		REGR factor score 2		REGR factor score 3	
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
1	0.344	1.68	0.353	1.37	1.95	1.48
2	-0.19	0.793	-0.07	0.637	-0.34	0.429
3	0.241	1.21	0.226	1.23	-0.23	1
4	0.011	0.833	-0.11	1.08	-0.03	0.691

Because the standard deviations are very high the confidence intervals are also very broad. Figure 2 illustrates the means and intervals for all 4 clusters on Factor 1. Only Figure 4, the organizer dimension, shows non-overlapping confidence intervals.

However when looking at Table 13 it shows that Factor 3, viewing the organizer tool, does not correlate with the GPA, confirming its non-significance to overall assessment.

Figure 2: Factor 1 group means.

Figure 3: Factor 2 group means.

Figure 4: Factor 3 group means.

Both, cluster 1 and 2 consisted mainly of South-Asian students whereas cluster 1 was more active than cluster 2. Since both share the same cultural background other reasons must exist why there is a difference. In a further step the executive student's educational background, age group, current location (domestic or expat), and job were analysed. It was found that in the more active cluster 1 there were significantly more SA working abroad as expats or either having their own business or planning to have and were on average 4 years younger. In most cases the first two attributes exclude each other; either a person is working as expat for a company or is running his/her own business domestically. Whereas one can easily understand that a business owner's intrinsic motivation to study may be higher than a normal employee, the fact that expats perform better is not that obvious. Their job and family demands are usually higher than those working in their home country. Therefore, one would expect that they have less time to study. Possible reasons why they perform better could be: rigid time management, high motivation, and fewer distractions. Many of Cluster 1 (Indian) students were working in the Middle East especially UAE. Combined with the fact that they are younger and therefore likely to be more career-oriented may make them better performing students. Whether a student just started or was close to the end of the programme made another significant difference. Students had to take 16 courses plus a Master Thesis in form of a project. Because the analysed course was an elective it could be taken as 5th course earliest and as late as 16th. More experienced SA students having at least done 10 courses performed significantly better than students taking it as 5th until 9th. It seems that there is a learning curve and maybe a motivational push toward the end of the programme to improve the final GPA.

4 CONCLUSIONS

We demonstrated that cultural differences in e-learning behaviour, assessment grade components, and peer assessment exist. A major issue in e-learning is whether the trend will be to greater convergence or more divergence (Edmundson, 2006). Greater convergence would mean e-learners worldwide are becoming more similar. More divergence would signify that e-learners are more likely to be significantly different (Blanchard and Allard, 2010). This study provided support for the divergence trend. One size will not fit all. Course design will need to be more adaptive not more generalisable. Unfortunately most e-learning courses have been designed by Westerners, including the analysed courses at the Singaporean university. However, the fastest-growing markets are non-Western: China and India.

5 IMPLICATIONS

Make students aware that there is a cultural bias.
Encourage EA to take the lead in group assignments.
Encourage SA to pull their weight in group assignments.

Make students aware that viewing the organizing tool reflects uncertainty avoidance but does not give a better grade.

Stress DB assessment criteria to EU to achieve more substance and less quantity.

Encourage students working as expats or planning to start their own business to share their experiences with others and serve as role model.

Further research in form of longitudinal studies (Goda & Mine, 2011) should take the behavioural changes over time into account as well as the impact of foreign exposure such as working as expat.

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Rule-based Automatic Adaptation of Collaborative Multiplayer Serious Games

Supporting Instructors in Game-based Learning Scenarios

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Keywords: Serious Games, Collaborative Learning, CSCL, Game Mastering, Adaptation.

Abstract: Computer-supported Collaborative Learning (CSCL) is a learning concept which is being used in schools and institutes of higher education for many years. In recent years, the concept of Serious Games offers new approaches for game-based learning. Combining the concept of multiplayer Serious Games with methods of CSCL to collaborative multiplayer Serious Games enables instructors to use game-based CSCL applications with a whole new way of control over the learning process and new ways of assessment. The cognitive load on an instructor during such a game, however, is quite high as the teacher needs to observe the gaming/learning process of a group of players/learners, monitoring and analyzing their behavior while moderating the learning process and coaching the learners. We therefore proposed a framework for supporting instructors with their tasks in collaborative multiplayer Serious Games using a generic description of such games defining necessary information about players and their interactions. The framework also defines possible ways of adaptation for the instructor. In this paper, we propose an extension of our framework which enables the instructor to automatize some of his/her tasks in order to reduce the cognitive load during monitoring and moderating the game-based CSCL process. We therefore designed a rule-based adaptation mechanism which is based on virtual agents. Using our framework, the instructor is now able to automatize some of his/her tasks before or during the game based on game facts and player behavior and learner progress.

1 MOTIVATION

Collaborative learning concepts are being used in schools and institutes of higher learning, as well as in various team-based training scenarios for many years. They provide an extension to traditional learning principles in which learners learn in groups, constructing their own knowledge. Social skills like communication, negotiation skills, or the ability to work in teams are vital for collaborative learning concepts to work (Dillenbourg, 1999), (Johnson and Johnson, 1999).

In recent years, the concept of Serious Games has become quite popular with a multitude of promising examples in various fields of application like game-based learning, simulations, games for opinion forming or for education. Serious Games are being researched for several years with many work focusing on how to design them (Harteveld, 2011) properly, how to integrate learning content into Serious Games in a seamless way (Wendel et al., 2011), or how to author Serious Games (Mehm et al., 2012), (Burgos et al., 2007a). However, especially in the field of multiplayer Serious Games, to the best of our knowledge, today there are not many Serious Game approaches or concepts, except for fire fighter or police training simulations like ViPol[1].

Combining the methods and concepts of CSCL with the concepts of multiplayer Serious Games offers new ways of game-based collaborative learning in groups. Therefore, it is necessary to develop concepts for multiplayer Serious Games and for collaborative Serious Games. It is known ((Dillenbourg, 1999), (Kollar, 2012)) that the role of the instructor is vital in collaborative learning scenarios. Therefore, it is a central task to develop methods and concepts for integrating and supporting the instructor in game-based collaborative learning scenarios. Moreover, as the instructor, or teacher will be the person to decide if such an application would be used in school, it is necessary to design such applications in a way such that the instructor feels confident using it. Therefore it is

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[1] http://www.polizei-online.de/p-online/Leistungen/virtuellestraining/Seiten/default.aspx

necessary to provide the instructor with all necessary tools he/she needs to fulfill his/her tasks. That means, the instructor needs to be able to observe the learning/gaming process of the group of learners and to control and adapt it when necessary. In (Wendel et al., 2012a), we provided a first approach for a framework for Game Mastering in collaborative multiplayer Serious Games. Our approach enables an instructor (in this context also referred as 'Game Master' (GM)) to monitor and analyze the game, its players, the players' behavior in terms of gaming, and their learning progress. It further allows the Game Master to adapt the game at runtime according to his/her professional opinion. Our framework enables the Game Master to have an overview over all relevant game and player parameters and to adapt them either directly or by triggering game relevant events.

The problem, a Game Master in this situation is faced with, is the fact that a lot variables need to be observed and maybe adapted throughout the game. This may overstrain the GM and keep him/her from concentrating on the most important aspects.

The main contribution of this paper is an approach to develop a concept to enable the Game Master with methods to automatize some of his/her tasks before the actual gaming session begins in order to relieve the cognitive load during the actual game session. Our concept makes use of the previously presented framework, using the Game Master interface to access game relevant date and parameters. Based on these, we provide the instructor with a Graphical User Interface (GUI) to create and modify rules using game facts and entities. Our concept models game relevant entities like the players through agents. Each agent periodically checks if a rule concerning the agent becomes true and fires the related game action.

We address the state of the art and technology related to our proposed research in Section 2. In Section 3, we describe the features and the functionality of our approach and in Section 4, we describe our prototypical implementation as an extension of the Serious Game *Escape From Wilson Island*. Section 5 concludes this work with a brief summary, preliminary results, and a description of future work.

2 RELATED WORK

2.1 Computer-supported Collaborative Learning

The term Computer-Supported Collaborative Learning (CSCL) is used to describe collaborative learning concepts enhanced with computer technologies (Koschmann et al., 1996). (Dillenbourg, 1999) described important mechanisms which are necessary for collaborative interaction to occur: The setup of initial conditions like group size or the group members' viewpoints, creating problems which cannot be solved with one type of knowledge, the definition of interaction rules, and the need for specific tools for the teacher to regulate interactions. While in early years of CSCL, the computer was rather used as a medium for communication (email, chat, forums, etc.) (Stahl et al., 2006), in later years more forms of CSCL have evolved. Many e-learning tools have been developed as platforms for collaborative learning (Horton and Horton, 2003), (Anjorin et al., 2011), (Hämäläinen et al., 2006), (Onrubia and Engel, 2009). Those tools either provide means for organization of collaborative learning processes, for group coordination, or for instructor support like group control and analysis.

In collaborative learning scenarios, the role of the instructor is especially important. The instructor has various important tasks to fulfill, like analysis, coordination, regulation of the learning process, and guidance or coaching of the learners (Olivares, 2007). The approach of (Konert et al., 2012) uses peer assessment in a Social Network environment with a special instructor support.

2.2 Game-based Learning

Digital game-based learning applications are existing for more than twenty years. Today they are regarded as one field of Serious Games addressing the playful mediation of learning content. In 2001, (Prensky, 2001) explained, why using games for learning can be a promising approach. He argues, that motivation is a key factor for learning, and games can provide the necessary motivation suggesting to combine gaming technology with learning concepts. The creation of games especially for this purpose is being researched under the term of Serious Games design. (Harteveld, 2011) is one very good example of a holistic design approach for Serious Games. Other interesting guidelines and models are (Kelly et al., 2007) or (Kiili, 2005). (Sandford and Williamson, 2005) provide an overview over Serious Games for use in school. They categorize (Serious) Games and use that categorization to identify how and where Serious Games can be used in school curricula.

(Squire, 2003) provides an overview over various forms and genres of games already being used in education, especially in classroom so far. He argues, that most of those games are either strategy games, simulations, or so called 'Drill-and-practice' games and explains their main application areas like using simulations to simplify complex systems like physics or politics. Other examples are military applications like flight simulators which today are also used in a non-military context.

Whereas the genres mentioned above are traditionally used to create single player Serious Games, there are also technologies for multiplayer Serious Games. The use of online roleplay games or SecondLife[2] in classroom has been researched by e.g. (Herz, 2001), (Delwiche, 2006), and (Steinkuehler, 2004).

2.3 Game-based Collaborative Learning

In recent years, research started to focus on the connection of collaborative learning and game-based technologies ((Voulgari and Komis, 2008), (Rauterberg, 2002)). Whereas (Hämäläinen et al., 2006) investigated the applicability of 3D games for collaborative learning, (Wang et al., 2009) defined a characterization of good educational games and a theoretical model for the improvement of learning in games through the incorporation of collaboration.

Based on the work of (Johnson and Johnson, 1999), (Zea et al., 2009) presented design guidelines enabling incorporation of features of collaborative learning in the video game development process. An approach for a 3D collaborative multiplayer Serious Game for learning with freely definable learning content is presented in (Wendel et al., 2010).

2.4 Game Mastering

The concept of Game Mastering in this context describes the adaptation and control of multiplayer Serious Games in terms of learning, gaming, and interaction.

(Dillenbourg, 1999), (Kollar, 2012), (Azevedo et al., 2005), (Hämäläinen and Oksanen, 2012) argued that real-time orchestration is vital for collaborative learning scenarios to be successful. However, (Hämäläinen et al., 2006) states that instructors are only insufficiently integrated when using game-based approaches for learning in groups or classes and thus are not able to orchestrate collaborative learning processes properly.

Various approaches can be found in literature addressing how to integrate the instructor into game-based learning approaches, especially in the field of multiplayer games. One approach originates in pen-and-paper approaches of roleplay games, where the Game Master needs to balance the needs, wishes and plans of the players with the task of telling a predefined story. These tasks are similar to those of an instructor who needs to balance individual learning and gaming preferences and learning speed to against the task of facilitating knowledge. Subsequently, one approach of (Tychsen et al., 2005) proposes a virtual Game Master based on the idea of the Game Master role in pen-and-paper roleplay games.

(Kreijns et al., 2007) state that technological environments can support teachers' abilities to foster productive knowledge construction by helping them to control and assess learning activities. (Wendel et al., 2012a) proposed a framework for instructor support in collaborative multiplayer Serious Games.

2.5 Adaptation Engines and Approaches

Adaptation in games aims at balancing a game and the players' experience of the game in a way such that players stay in the flow area (Sweetser and Wyeth, 2005). This means players are neither bored nor overchallenged by the game's difficulty. This also means that the game's pacing is neither too slow nor too fast. In games, there is a distinction between direct adaptation and indirect adaptation. While the former refers to a direct specification by the game designer of how to react on certain game states, the latter uses feedback from the game world to calculate a possible adaptation. Direct adaptation, thus needs a lot of predefined situations but once such a situation occurs, the respective adaptation can be triggered. Indirect adaptation, however may be very complex due to the amount of possible reactions and their effects on the game ((Manslow, 2004), (Westra et al., 2009)).

In Serious Games, adaptation not only balances the game in terms of flow or fun, but also in terms of the state of the learners and their progression (Sottilare and Gilbert, 2011). It is however rather difficult to gather information about the learner (state/progression) and to find appropriate adaptations (Brusilovsky, 1998).

The approach of (Vassileva and Bontchev, 2009) is rule driven. It strongly separates adaptive rules from business logic to guarantee an ability for editing adaptive rules at runtime. Other approaches are based on IMS Learning design, like (Morenoger et al., 2008), (Moreno-Ger et al., 2007), and (Burgos et al., 2007b). They all focus on adaptive Serious Games and their design. The 'IMS Learning Design' mainly represents and encodes learning structures and methods for learners and teachers and is "focused on the design of pedagogical methods able to manage learning activities linked to learning objects within a learning

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[2] secondlife.com

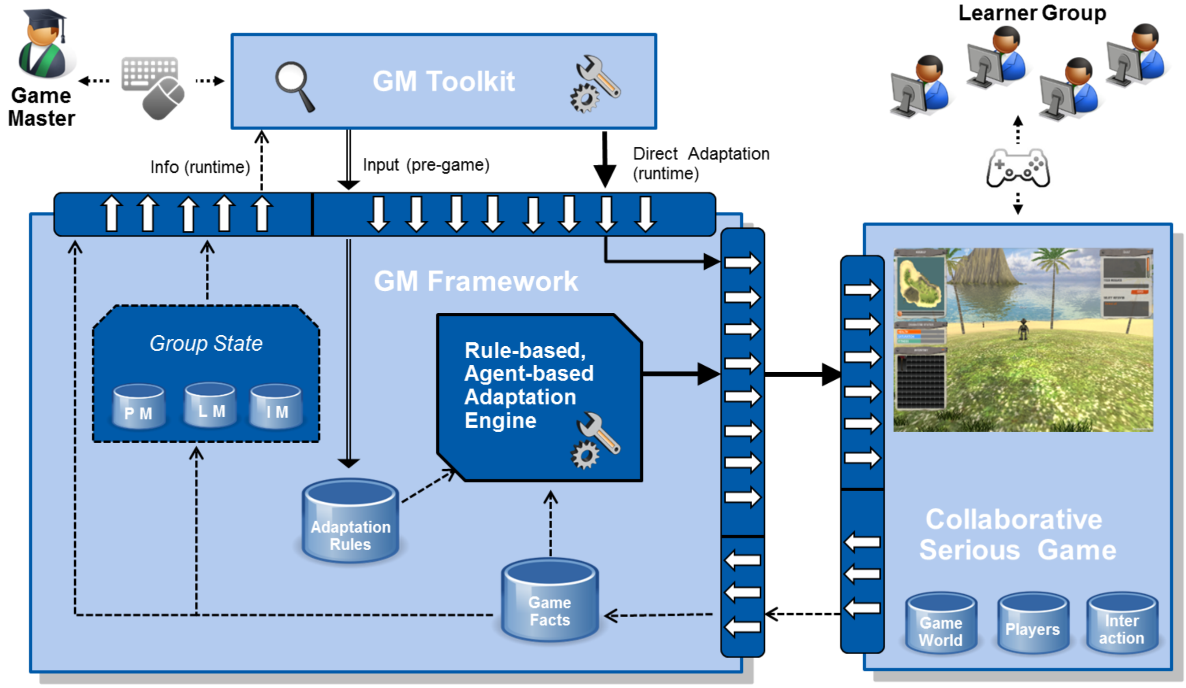


Figure 1: Game Mastering Framework Architecture.

flow" (Burgos et al., 2007b). Agent based approaches like (Westra et al., 2009) divide the game into its relevant elements like the players, characters, or other elements especially important for the game (e.g. the simulation of fire in a fire fighter simulation).

Each of these elements gets assigned an agent which is responsible for adaptations concerning its element. (Charles and Black, 2004) use neural networks for player modeling and use their framework for adaptation of the game focusing on the player. (Chellapilla and Fogel, 1999) present an overview over neural networking related to adaptation in games. (Ram et al., 2007) use case-based reasoning. It stores a set of past game situations and their respective solutions and tries to apply them to similar cases.

Another approach for adaptation in Serious Games is the concept of Narrative game-based Learning Objects (NGLOB) which are being used in the context of the European research project 80Days (Göbel et al., 2010), (Kickmeier-Rust et al., 2008).

3 OUR APPROACH

Our approach is an extension of our Game Master framework presented in (Wendel et al., 2012a) which was designed to support Games Masters in collaborative multiplayer Serious Games by providing a generic description and an interface for 3D collaborative multiplayer Serious Games. The framework gives Game Masters ways to observe and analyze such a game and to adapt and direct in in the desired way. Therefore, the Serious Game using the described interface informs the framework about game relevant parameters and adaptable parameters and events to trigger. For more details about the design of the game with focus on collaboration see (Wendel et al., 2012b).

3.1 Architecture

The extension to our framework which we describe in this paper, uses a combination of a rule-based an an agent-based adaptation engine. Its goal is to assist the Game Master by relieving the cognitive load during the gaming session. Our extension enables the Game Master to create adaptation rules. Those rules will automatically trigger adaptations like parameter adjustments or game events when their conditions become true. Therefore, the Game Master is able to intelligently automatize some of his/her tasks, thus being able to concentrate on other tasks.

Our framework, in the center of Figure 1 connects the players / learner group (right top) with the Game Master (left top). Via the Game Master interface (big white arrows), the framework is connected to the game itself (right side) and the Game Master toolkit (top left side). The framework contains a database of game facts where all facts about the game (game

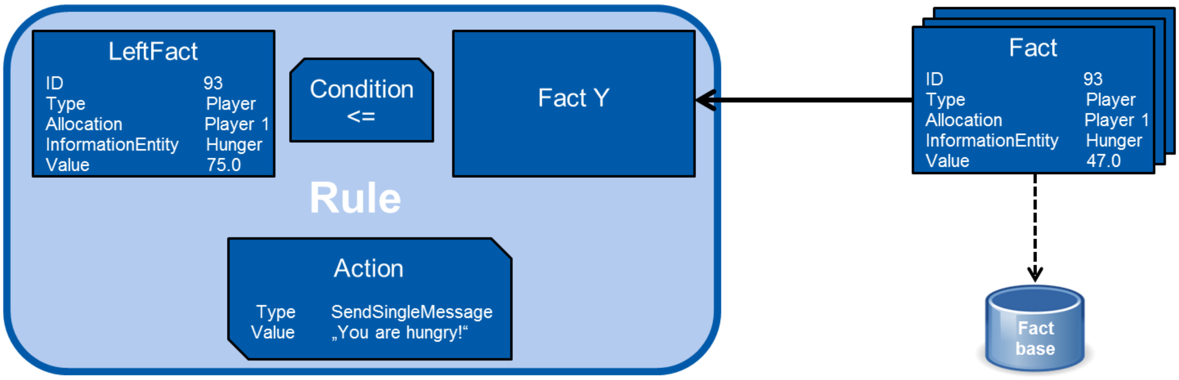


Figure 2: Rule Components.

state, time, players' states, etc.) are stored. It further contains a set of adaptation rules. It also contains the Group State, the combined state of the group's player model, learner model and interaction model.

The GM-Interface enables the Adaptation Engine (AE) to have a generic knowledge over game elements, parameters, and actions. Via this interface, the framework knows, which facts exist in the game and which actions can be triggered. These information is necessary in order to know which game facts can be used to specify a rule and which actions a rule can trigger in the game. Game information is told to the framework from the game and is stored in the game facts database. That information is passed on to the GM toolkit in order to present them to the GM. It is also used for the Adaptation Engine. Via the GM Toolkit, the GM can directly adapt the game. That information is passed through the framework directly to the game. The GM also defines rules via the GM toolkit. Those are stored in the Adaptation rules database. Those facts are also used for the adaptation engine. Altogether, the adaptation engine gets game information from the game (Game Facts) and rules from the GM (Adaptation Rules) and adapts the game using both inputs.

3.2 Adaptation Engine

In the following part, we will explain the Adaptation Engine in detail. The AE checks predefined rules and triggers actions, if a rule's condition is fulfilled. The rule consists of the following parts: Fact, Condition, and Action. Facts are stored in the FactBase and rules in the RuleBase. The FactBase and the RuleBase are essentially only replica of the Game Facts database or the Adaptation Rules database inside the GM Framework.

A rule (see Figure 2) contains a so-called LeftFact. The LeftFact is defined by the author (the GM) of the rule. The LeftFact defines

- ID: unique identifier for the fact
- type: player, non-player character, game, time
- allocation: depending on the type, e.g. for player: concrete player (by name, id, role, or item in inventory)
- *informationEntity*: specifies the attribute or variable connected to the allocation (e.g. health)
- value: the value of the fact.

During evaluation, the LeftFact gets compared to an actual fact (FactY) from the FactBase using a condition. A condition can be $=$, $\neq$, $<$, $>$, $\leq$, $\geq$, 'and', 'or'. Facts can be combined with boolean 'and' and 'or', so that complex condition terms like '$a < b$ and $b = c$' are possible. If the condition becomes true, the corresponding action will be executed. The actual AE (see Figure 3) consists of

- the Rule Engine module,
- the Agent Engine module, and
- the Managing module.

3.2.1 Rule Engine Module

The Rule Engine Module contains the set of rules (RuleBase) and is responsible for evaluation of rules. The Rule Engine decides whether a rule condition is fulfilled. It therefore compares the Leftfact of a rule with the set of facts from the FactBase. There it searches for a fact with the same type, allocation, and *informationEntity* like defined in the LeftFact. If such a fact is found, the value of that fact is compared to the value of the LeftFact using the corresponding condition.

3.2.2 Agent Engine Module

The Agent Engine module manages all agents. Each entity in the games (players, NPCs, the game itself)

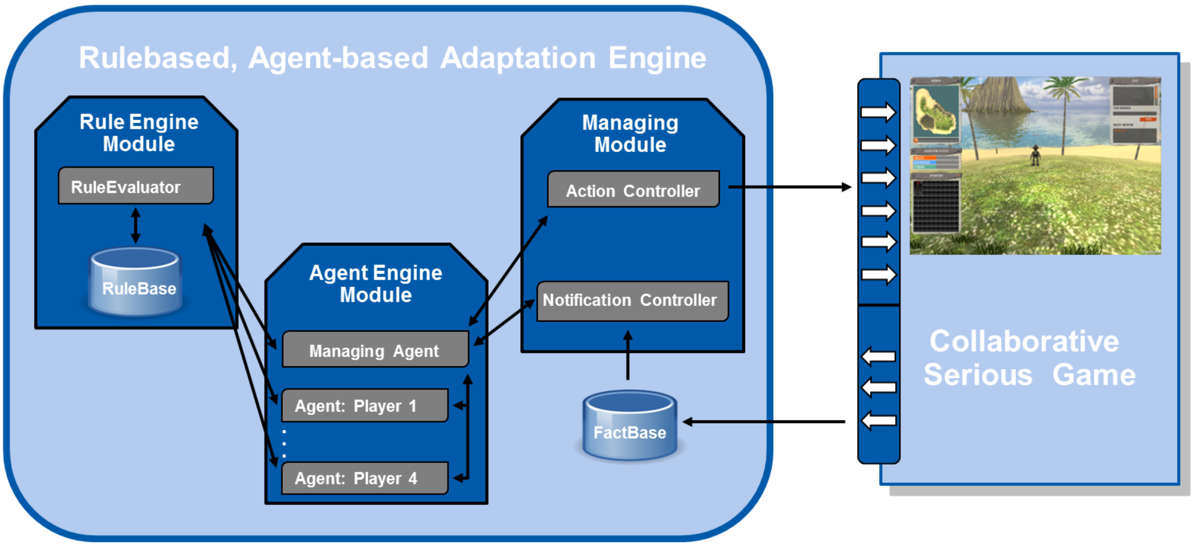


Figure 3: Adaptation Engine Modules.

has one agent which is responsible for updating the entity's parameters. Additionally, there is a Managing Agent which creates all other agents and manages communication with them. The Managing Agent processes information and data via notifications to other agents. A notification is used to e.g. trigger an update of a fact related to an agent (like the health value of a player). Only the Managing Agent communicates with the game directly, all other agents communicate with the game via the Managing Agent.

3.2.3 Managing Module

The Managing Module contains the Notification Controller and the Action Controller.

The Notification Controller transfers notifications from the Serious Game to the AE, i.e. to the Managing Agent.

The Action Controller is a buffer for actions to be triggered. It collects all actions which should be performed and assures that actions are not repeated too early after their first execution. Therefore, each action es tagged with a timestamp. Furthermore, for each action, an action repeat interval is set, defining the minimum time between two executions of one action. When an action is allowed to be triggered, the Action Controller passes the action to the game.

3.3 Workflow

In this paragraph, we want to illustrate the typical workflow of the AE (see Figure 4).

Whenever something relevant in the game happens, the game sends a notification to the Game Master framework, which updates the FactBase and notifies the Managing Module (Notification Controller). The notification controller then notifies the Managing Agent which processes the notification and sends an AgentEvent to the respective agent. The agent then checks its rules for change using the Rule Engine. The Rule Engine decides whether an action should be fired. If so, it notifies the agent which sends an ActionAgentEvent back to the Managing Agent. The Managing Agent adds the action to the buffer of the action controller inside the Management Module. From there, the action is passed to the game, if the action repeat interval is valid, i.e. the same action has not been executed recently.

4 PROOF-OF-CONCEPT

4.1 Escape From Wilson Island

As a proof-of-concept, we implemented our approach as an extension to the existing Serious Game prototype *Escape From Wilson Island*.

Escape From Wilson Island (*EFWI*) was designed as a collaborative multiplayer Serious Game for four players. It is a 3D action adventure created with the Unity3D game engine. As a narrative background, we chose a 'Robinson Crusoe'-like scenario with the four players being stranded on a lonely island from which they need to escape. In order to succeed, the players need to fulfill several tasks. They need to secure their surviving by finding food and shelter. Then they need to build a raft and steer it to a neighboring island with a high mountain on which's top they need to establish

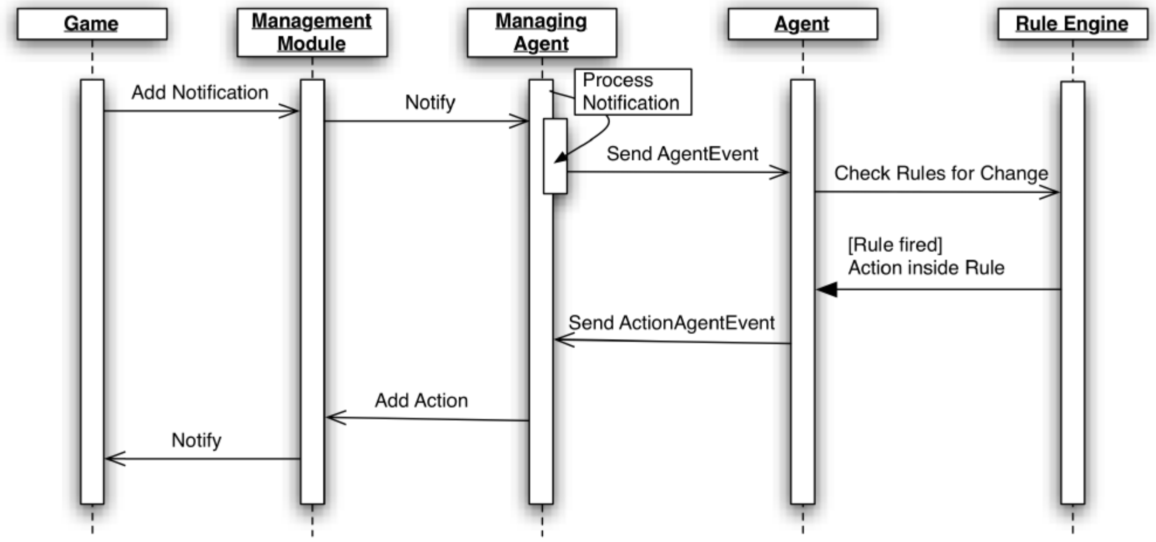


Figure 4: Adaptation Engine Workflow Diagram.

a signal fire. Several secondary tasks need to be fulfilled throughout the game. All of those tasks require the team to either work together directly (like carrying a palm together) or divide work among them (like one player gathering food while other players carry a palm). A Non-Player Character (NPC) was implemented as a mechanism to help players. The NPC provides tips and tells the players which tasks they have to fulfill.

Our Game Master framework was integrated into *EFWI* by implementing the GM frontend into the game itself. The Game Master framework was added as an additional module to the game. Game Masters now can oversee the whole game by moving freely in the 3D world or by following one or more players automatically via splitscreen technique. The Game Master can also control the NPC by adapting dialogues or creating completely new ones. The GM can adapt the game by adjusting player relevant parameters like the rate of hunger per unit of time or its counterpart, the rate of saturation restored when eating food. Apart from these parameters which directly influence the degree of difficulty, the GM can modify the game world by placing or removing palms or berry bushes. Thus, the GM can indirectly manipulate tasks like building a log hut for shelter or the task of finding food.

4.2 Facts and Actions

As mentioned in Section 3, we have the following fact types: player, NPC, game, and time. In *EFWI*, the following allocations are specified via the Game Master interface:

- Player
  - All (all players)
  - Player Name (player with the specified name)
  - Player Role (role chosen at game start)
  - Player With Item X (players having the specified item)
- NPC
  - Hank Toms (name of the only NPC in the game)
- Game
  - Game (there is only one allocation for the type game: the game itself)
- Time
  - Time (there is only one allocation for the type time: the game runtime)

We further want to describe some of the *informationEntities* defined for the type player:

- Hunger (direct player variable)
- Tiredness (direct player variable)
- Health (direct player variable)
- FelledPalm (first time)
- GatheredBerry (first time)
- CarriedPalm(first time)
- NumberOfFelledPalms
- NumberOfBerriesGathered
- IsOnRaft
- WalkedDistance

```
11:02:56 AM: Florian ate a berry.(Florian)
11:02:54 AM: Floriangathered berries.(Florian)
11:02:19 AM: Florian ate a berry.(Florian)
11:02:16 AM: Floriangathered berries.(Florian)
11:00:00 AM: Florian ate a berry.(Florian)
10:59:56 AM: Floriangathered berries.(Florian)
10:59:04 AM: Florian ate a berry.(Florian)
10:59:02 AM: Floriangathered berries.(Florian)
10:58:47 AM: Florian ate a berry.(Florian)
10:58:44 AM: Floriangathered berries.(Florian)
```

Florian	Viktor	Christian	Johannes
Health: 50.2	Health: 50.2	Health: 50.2	Health: 50.2
Saturation 53.7	Saturation 33.7	Saturation 32.9	Saturation 32.6
Fitness 7.8	Fitness 0.1	Fitness 0.1	Fitness 0.1

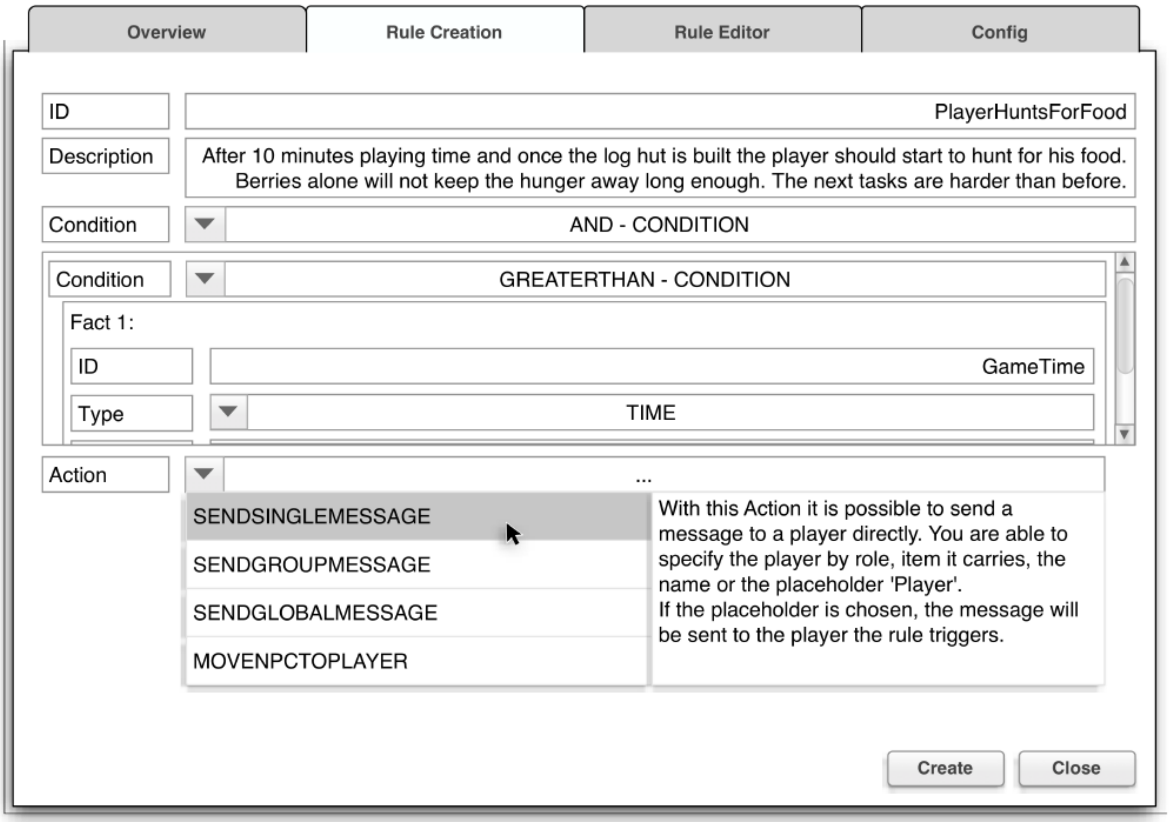
Figure 5: *Escape From Wilson Island* Screenshot.

- Position

Similar *informationEntities* were specified for the other types, which we will not list here in detail. However, the *informationEntities* defined are a complete list of parameters and actions to be triggered in the game so that the Adaptation Engine has the same power regarding possible adaptations than the Game Master has using the Game Master toolkit.

As a next step, we want to explain our decisions to use exactly those *informationEntities*. Hunger, tiredness, and health are the three main player variables which define the player's current condition. Felled-Palm, and other 'first time' variables are necessary for the Game Master to recognize problems. If the player possessing the axe did not fell a palm after several minutes, it is likely that he/she either did not understand how to do it or that it is necessary to fell palms in order to win the game. In both cases the GM might want to interfere. Using this *informationEntity*, the GM can set up a related condition and trigger an action containing a notification for the player telling him/her how to use the axe to fell palms. Other *informationEntities*, like 'IsOnRaft', or 'Position' can be used to determine what the player is doing. Values are either numeric or boolean.
The following examples can be used as actions by the Game Master:

- setHungerPerTime
- seDamagePerEvent (suffocation or falling)
- setSaturationPerEating
- setHealthRegenerationPerNight
- set TirednessPerAction
- setFitnessRegenerationPerNight
- plantBerryAtPositionXY
- plantPalmAtPositionXY
- removeBerryBushAtPositionXY
- removePalmAtPositionXY
- setCurrentStrength (currents in the sea while steering the raft)
- sendNotificationToPlayer
- sendNotificationToGroup



ID: PlayerHuntsForFood

Description: After 10 minutes playing time and once the log hut is built the player should start to hunt for his food. Berries alone will not keep the hunger away long enough. The next tasks are harder than before.

Condition: AND - CONDITION

Condition: GREATERTHAN - CONDITION

ID: GameTime

Type: TIME

Action: ...

With this Action it is possible to send a message to a player directly. You are able to specify the player by role, item it carries, the name or the placeholder 'Player'.
If the placeholder is chosen, the message will be sent to the player the rule triggers.

Figure 6: Interface for Entering Rules in *Escape From Wilson Island*.

- MoveNPCToLocation
- MoveNPCToPlayer
- changePlayerAttribute

Altogether, the GM is now able to define conditions related to game facts to adapt player values, game parameters, or the 3D game world itself in the desired way by setting up appropriate rules.

4.3 Frontend Concept

Rule specification is executed using the following graphical interface (Figure 6).

The GM can edit existing rules and create new ones. When creating a new rule, the GM specifies a name and a description for the new rule. Then, a condition is selected. Creating the LeftFact is done by selecting a type. Once the type is selected, the GUI provides the list of valid allocations. Then a list of valid *informationEntities* is provided of which the GM selects one. After that, the GM specifies the desired value. In the next step, the GM defines the related action. All possible actions are again provided as a list of which the GM selects one and specifies values, if necessary (e.g. changePlayerAttribute: attribute health, value 50). The GM can specify more than one action here.

5 CONCLUSIONS AND FIRST RESULTS

The main contribution of this paper is the development of a concept for assisting instructors at orchestrating collaborative multiplayer Serious Games. We provide a reference architecture framework for 3D collaborative multiplayer Serious Games for a small group of players. We also provide a concept for an adaptation engine which enables the instructor to automatize parts of his/her work.

We proposed an approach for a rule- and agent-based automatic adaptation of collaborative multiplayer Serious Games according to an instructor's preferences. Our approach can be used to reduce the cognitive load on a Game Master during a session of a collaborative multiplayer Serious Game. It is an extension of the Game Mastering framework we proposed in an earlier work. Using the Game Master interface, our extension knows about game facts and the overall game state end uses those together with previously by the Game Master defined rules to adapt a game ad-hoc. Our architecture contains an Adaptation Engine module which enhances the Game Master framework. Our architecture also defines the interface between the game, the framework, and the Game Master toolset.

As a proof-of-concept, we implemented our extension of the framework using the existing Serious Games prototype *Escape From Wilson Island*. We then defined a set of in game facts which are specifically relevant to the Game Master in this game.

Initial studies with two non-professional Game Masters and groups of four students as players have shown that the extension to the GM Framework is applicable for instructors. After a first gaming session without the use of the Adaptation Engine, they realized which game actions they would repeatedly use in order to adapt the game. Consequently, they created rules connecting those actions with the respective game conditions. Thus, they stated that they indeed had a less cognitive load during the second session where their rules were used to automatically adapt the game. However, although these preliminary results are promising, more comprehensive studies, including real instructors, i.e. teachers, are necessary in order to prove the effectivity of our automatic rule- and agent-based adaptation framework.

The work described in this paper is limited to a certain genre of Serious Games: The game needs to be a multiplayer game for a small group of players (3-6). The game mechanic needs to support collaborative actions throughout the game including communication and interaction between players. The game needs to implement the interface described above in order for the adaptation engine to be able to receive game information and to send back adaptation commands to the game.

Next steps will include an evaluation with four to five teachers and 40 to 60 students from vocational schools (metal workers and cooks). Important results would include knowledge about how the Adaptation Engine is used by different instructors and to which extend the cognitive load on them is reduced by giving them the opportunity to automatize a part of their tasks. Furthermore, our Game Master framework including the Adaptation Engine should be transferred to other collaborative multiplayer Serious Games. The Serious Games prototype *Woodment*[3] would be very well applicable for this.

The future research direction of this work will go towards a holistic approach for adaptation of game-based collaborative multiplayer approaches whereas adaptation is applied in terms of learning, gaming, and interaction. The goal is to optimize such an application/game in terms of learning success, fun (gaming), and interaction (collaboration).

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[3] demos.storytec.de/woodment_gameplay

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Badge Architectures in Engineering Education
Blueprints and Challenges

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Keywords: Badge Architectures, Achievements, Gamification, Motivation, Reputation, Engineering Education.

Abstract: The paper presents a critical discussion of badge architectures and an illustrative case study. We argue that common glosses of badges as simplistic or as extrinsically motivating are misleading when designing or evaluating badge architectures. We propose to focus on their descriptive and creative effects: badge architectures may create user portraits, system maps, and dedicated timelines, supporting new forms of attention within the system and at meta-system levels. By affording new activities in and about the system, badges can offer participants resources to internalize their extrinsic motivation. Our case study illustrates the complexity of minimalist badge architectures, presents two innovative features, and discusses challenges in implementation.

1 INTRODUCTION

In this paper we critically review and reformulate arguments concerning the use of badges, and we propose orienting concepts for designers of instructional systems. There is a rich thread of literature dedicated to badges and related reward systems in digital games; nonetheless, their use in education, and particularly in engineering education, has been rather understudied. Badges are mainstream components of digital games, and they are increasingly used in non-game contexts and in boundary systems (serious games, gamified applications, games with a purpose). This increasing interest in badge architectures reflects two converging trends: on the one hand, their continuous evolution and growing importance in gaming, and, on the second hand, the expanding relevance of games as models and resources for the design of other systems.

The paper is organized as follows: in the next section we define badge architectures and discuss their key features and rationales; we then discuss specific issues concerning badges in educational settings, and we present a case study to illustrate some of our key points. We conclude by proposing a new set of concepts to guide reflection on the design and evaluation of badge architectures.

2 BADGE ARCHITECTURES

We use the concept “badge architectures” instead of simply “badges” in order to underline one of our main arguments: badges are valuable as components of a system of rewards, related, in turn, to a system of activities. Awareness of the systemic functioning of badges is a key consideration for the design process.

Seen from a critical distance, badges may seem a simple or even simplistic mechanic. Still, successful badge architectures often balance multiple objectives and combine heterogeneous elements to create smooth user experiences. Their apparent simplicity is, at its best, a sophisticated achievement of design and evolution.

2.1 Key Features

We cover by the term “badges” a variety of rewards, including “achievements”, “medals”, “trophies”, “pins” etc. Some of the key features shared by these rewards are: a title, an icon, a description and related points (Galli and Fraternali, 2012). Badges are virtual artefacts that are granted to participants, who thus become their owners. If we extend the description of badges to include their role in the system, we can say that, as a rule, a badge shares the following characteristics:

1) A **graphic sign**: as a rule, badges have a core graphical descriptive component, which may be complemented with additional elements such as text, numbers, and/or other graphical elements (for example, several stars);
2) A reference to a specific **system event** resulting from the user's activity; this may be an accomplishment of a valuable task, a chance finding, a noteworthy failure (for anti-achievements), a memorable experience etc. The event is, as a rule, succinctly described through the badge title and possibly through an accompanying phrase; badges may allow observers to reach (via hyperlinks) a more elaborated description of the underlying activity and performance;
3) After it is unlocked, the badge is attached to the **participant's profile** in the system and, possibly, transferred in other systems as well;
4) Badges rely on a **quality vs. quantity** play: they are virtual possessions, and, as such, can be either possessed, or not. Still, badges may be further quantified (by counting them, or by summing achievement points), thus becoming again commensurable on a continuum.
5) Badges often are **secondary rewards** (Montola et al., 2009), meaning that the game can be played without paying too much attention to them; nevertheless, many players consider the secondary achievements a critical game element (Jakobsson, 2011).

a. Rationales

Badges in digital games are diverse. Montola et al. (2009) identify several types, ranging from rewards for exploring the game (tutorial) and completing game activities (completion, collection) to badges for outstanding achievements (virtuosity, hard mode, veteran, loyalty, paragon), for eccentric events (special play, curiosity, luck) and to meta-gaming (fandom). This diversity makes visible several functions of badge architectures in digital games: they show the way, they render visible certain activities and stimulate participation, and they encourage prolonged engagement with the game. From the point of view of game designers, achievements are especially valuable insofar they retain players longer in the system. Antin and Churchill (2011) point to five other functions of badge systems: 1) instruction about possible activities, 2) goal setting, 3) reputation – including information on players' experiences, skills, interests, and overall dedication to the game, 4) conferring status, and 5) group identification. They go on to highlight two topics for further reflection: badges are not motivational for all participants, and they may even have adverse effects by displacing intrinsic motivation.

Given the diversity of participants, the diversity of possible badges, and uncertainty concerning motivational effects, how are designers to tackle the task of deciding whether a given badge architecture is adequate, and how to implement it?

We propose to distinguish between two functions of badge architectures that are analytically distinct while depending on one another for functioning: a **descriptive** mission, and a **creative** mission.

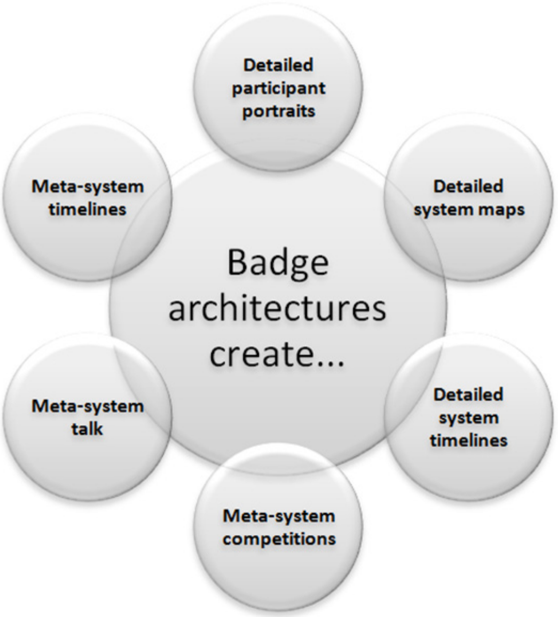


Figure 1: Creative effects of badge architectures.

On the one hand, badge architectures function to **map the system** of activities (game or non-game) to which they are attached. Badge architectures also function to **portray** participants, making their experiences, skills, and inferred preferences available to others, in a system of coveillance (Jakobsson, 2011). One step further, by specifying valuable activities and outcomes in the system, and by making participants visible to one another, badge architectures allow a "**Gestalt understanding**" (Antin and Churchill, 2011) of the system and its community.

On the other hand, through this descriptive effects, badges afford novel **activities within** the system and **about** the system (such as various metagaming activities – Sotamaa, 2010), and new sets of **reasons** for engaging with the system. In his ethnographic work on Xbox 360 gaming, Jakobsson distinguishes three main types of users in relation to achievements: achievement casuals (enjoying them now and then for their scaffolding function), hunters (aiming for the largest overall score), and completists (aiming for an integral achievement collection) (Jakobsson, 2011). We identify, through his analysis, three creative effects of badge architectures that apply to games and possibly to other systems as well. On the one hand, they add a **resistance structure** to the gameworld, by making salient the less visible regions of the game, by structuring gameplay time, and by extending the duration of gameplay beyond the first game end. Secondly, badges create a **new definition of game completeness**: they compose a collectable set that invites a new type of activity: "collecting badges". Thirdly, as Jakobsson notices, badges may create **a different (meta)game** whatsoever out of a series of initial games: he concludes that players of the Xbox 360 console games have become, with variable awareness and willingness, participants in a multi-player online game in which each achievement represents a distinctive "quest".

A focus on the descriptive and creative missions of badge architectures allows us to overcome the heated debate on whether badges foster **intrinsic or extrinsic motivation**. Badges are often denounced as depleting activities of their fun, displacing intrinsic motivation, or making it irrelevant, at minimum. Laschke and Hassenzahl (2011) join a trend of denouncing badges (and other instances of gamification) as meaning-depleting stimuli that enforce a behaviorist theory of human motivation (Robertson, 2012; Hecker, 2010; Bogost, 2011). Still, their argumentation does not rely on empirical evidence on how badges are actually taken over by participants. They notice that "becoming a "mayor" of a place can be solely driven by the wish to get the according badge (…) there might be a big difference between being there because of an intrinsic interest in the people, the place, the atmosphere or being there because of the badge" (Laschke and Hassenzahl, 2011, p. 3). While this difference certainly *might* obtain in some instances, empirical research and testimonies concerning Foursquare users / players point out that many of them have multiple reasons for using the system, beyond collecting badges (Lindqvist et al., 2011) – even when cheating in the game (Berne, 2012). Jakobsson replies to the intrinsic vs. extrinsic discussion that badge collecting is in itself an intrinsically motivated pursuit – but this does not directly address the issue of whether the joy of collecting decreases the joy of playing or otherwise engaging with a system. Jakobsson notices that, in practice, there is a deep ambiguity of players concerning achievements. They can be experienced as stimulating, as addictive, as alienating, or as informative and quasi-inert – depending on the game the participants actually play, within the formal system frame (ibid.). The question then becomes not whether badges support or displace intrinsic motivation, but **what kind of novel activities are afforded by badge architectures**, how are they taken over by participants, with what kinds of reasons, and with what consequences? These questions can only have specific, empirical answers, depending on the social context of the activity.

3 BADGES IN EDUCATION

Badge architectures in educational systems may be **embedded into a gameful system** (see for example Fitz-Walter, 2011), or may be used as **independent game-like mechanics** to animate non-game learning activities, as in the examples of the Khan Academy and the future MITx framework (Young, 2012), in Mozilla Open Badges (Goligoski, 2012) or in the RSS Network (Ross et al., 2012).

Unlike gameplay that is, more often than not, voluntary and driven by enjoyment and other forms of individual fulfilment, students often experience educational activities as dry and tiresome beyond enjoyment. Therefore, the issue of intrinsic motivation displacement is less salient for badges granted in non-game learning systems. The problem becomes, rather, one of attention focus, for instructors and students as well. Badge-fuelled instructional systems may be accused of being lazy: do badge architectures stimulate instructors to create relevant, engaging learning experiences, or do they rather relieve them of this pressure? Do they stimulate learners to seek the hidden logic and relevance of unfamiliar notions, or just to navigate the surface of the subject matter and collect badges?

On the other side, badge architectures promise significant motivational effects for potential recipients – be they students or teachers. Final, outcome-badges are especially valued for their **descriptive** force: unlike diplomas, they are specific about underlying experiences and skills, and they can be displayed immediately after they are 'unlocked', making personal growth visible on a continuous basis (Young, 2012). Badges provide a form of fast (if not immediate) feedback, and they offer resources for self-presentation in front of peers and employers. Unlike badges in digital games, which are of interest mainly for other gamers and designers, badges in educational systems can speak to a larger set of publics, including potential employers in various fields, peers, and family members who may belong to different generational and occupational worlds. Educational badges may function, therefore, as **boundary objects** (Star and Griesemer, 1989; Halavais, 2011), translating formulations of skills and experiences to support interaction across domains of expertise.

There is another reason to consider the motivational force of badges in education. At finer levels of task granularity, badges that reward intermediate progress or secondary performances make the participant more aware of, and invested into the system. The **self-determination theory of motivation** (Scott Rigby et al., 1992; Ryan and Deci, 2000) downplays the intrinsic / extrinsic distinction and brings forward the issue of internal versus external source of motivation. Insofar badges offer pretexts for engaging with an activity, moments of fun that give some impetus for tackling a difficult task, they become antidotes for procrastination. Badges may function as tools for internalizing extrinsic motivation, enhancing participants' self-determination. Learners often appreciate that study tasks are useful and relevant – but they may lack a here-and-now impetus for actually starting the work. Getting the work started, for reasons intrinsic or extrinsic to that activity, is the first step towards developing better appreciation of a competence field, a first and necessary step towards autonomous learning. Badge architectures can therefore be designed not as promoters of intrinsic motivation, but as a **scaffold** for what Ryan and Deci (2000) call **internalized extrinsic motivation**, which we think of as a quasi-intrinsic motivation.

The third reason for considering badge architectures as motivational tools derives from their creative effects. Badges can consolidate learning by producing structures that extend beyond the here-and-now of instruction:

- Architectures of badges create **maps of learning fields and communities of practice** (Lave and Wenger, 1991). Therefore, they may support a better understanding of what is relevant in a specific field, and they can encourage convergence between different stakeholders in formulating the curriculum: human resource experts in the industry, K12 and university professors, and students;
- Unlike the too-official grades, badges "give concrete evidence for bragging rights" (Jarvinen, 2009) through detailed participant portraits, and thus stimulate **conversations** around learning; badges can also support consistent **contributions** on forums, peer-learning and content generation;
- Grades are only for students, but badges are for students and teachers alike, linking them in **horizontal social networks**; this is particularly relevant given the opportunities of social web for education (Trauşan-Matu et al., 2009);
- Badges afford comparisons between students and teachers from different course years, crossing classroom and generational time borders; they create **extended timelines**;
- Badges create **communities** of members that are attentive to one another's progress and even compete in educational arenas.

4 CASE STUDY: RL Hit List

In order to illustrate some challenges in designing badge architectures, we present the "RL Hit List". We have designed this system for students in the Computer Networks course (abbreviated as CN, in translation as RL) taking place in the 3rd year of study in a Computer Science program of a European technical university. The course enrolls around 100 students. The Hit List is already in use: its first 21 badges were awarded to course instructors and organizing team members, and the next 25 badges will have been awarded by the end of the first semester, in February 2013. The objectives of this badge system are:

1) To assemble **communities** of students and teachers:

- To create a visible, public, and course-related merit-based elite of students, including around 25% of each generation;
- To create a trans-generational record of performance, linking instructors and students from different years in a common network;
- To raise interest in computer networks and in the CN course among top performing students, and to recruit future student mentors and TAs;
- To position the CN course as a meaningful, challenging learning experience for students, instructors and employers alike – and in this process to consolidate the identity of the CN instructor team, and the research group in which they belong;

2) To stimulate technical and casual **talk** referring to computer networks and the CN course

- To make student performance throughout the course a public matter and a topic for conversation – that is, to create what Jarvinen aptly called "evidence for bragging rights" (2009) related to the CN course concepts, participants, and memories;

this evidence can become a topic in students' talk with their colleagues, and also in interactions with significant others from other professional fields, including family members and friends;

- To stimulate joint reflection in the faculty group – as teaching assistants are the ones who deliberate and vote on the students that receive badges for their laboratory and overall contributions.

- To position performance in the CN course as an 'experience that makes a difference' in students' CVs and when interviewing for jobs in the IT&C industry;

3) Last but not least, to **motivate** students to engage with course, laboratory, and forum activities, to raise their interest for participating in attendance-monitoring systems (Bucicoiu and Ţăpuş, 2013), and for obtaining top grades in midterm and final examinations.

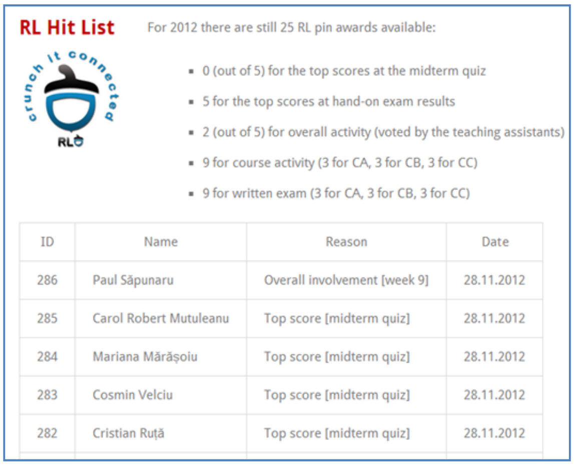
The RL Hit List falls squarely in the set of badge architectures, but it has two distinctive traits:

- It combines digital and material rewards: each prize consists in a digital inscription and a metallic pin badge (Figure 1), which is ceremonially awarded at the beginning of a course;

- Instead of images, it uses numbers as visual signs (Figure 2): each recipient receives an ID number on the Hit List, in increasing chronological order. The initial number was 256, the first value to symbolically evade representation on one byte. ID numbers do not represent scores or levels, but marks in time – which, at the same time, serve to construct a distinctive timeline and a tradition in reference to the CN course. The system displays a minimalist graphic, aimed at a community of professionals, with no explicit reference to gamefulness or playfulness.

Figure 2: Metallic pin badges for the RL Hit List.

The allocation of RL pin badges is not entirely automated, depending, for some categories, on instructors' deliberation. As a consequence, this award architecture has immediately produced a new kind of **awareness** of possible and alternative criteria for appreciating student contributions to classroom and virtual discussions. In order to be able to make their case, members of the course team have had to pay more attention and to remember more of their students' activity in class, by name. Although it seems that teaching assistants and course professors would anyway remember outstanding students, setting this as an objective visibly refines the granularity of the remarkable contributions.



RL Hit List

For 2012 there are still 25 RL pin awards available:

- 0 (out of 5) for the top scores at the midterm quiz
- 5 for the top scores at hand-on exam results
- 2 (out of 5) for overall activity (voted by the teaching assistants)
- 9 for course activity (3 for CA, 3 for CB, 3 for CC)
- 9 for written exam (3 for CA, 3 for CB, 3 for CC)

ID	Name	Reason	Date
286	Paul Săpunaru	Overall involvement [week 9]	28.11.2012
285	Carol Robert Mutuleanu	Top score [midterm quiz]	28.11.2012
284	Mariana Mărășoiu	Top score [midterm quiz]	28.11.2012
283	Cosmin Velciu	Top score [midterm quiz]	28.11.2012
282	Cristian Ruță	Top score [midterm quiz]	28.11.2012

Figure 3: The online RL Hit List at 28.11.2012.

While virtual badges are swiftly allocated by system administrators, metallic pins are awarded festively, in front of around one hundred colleagues. Still, this feeling of ceremony is volatile: we have noticed that, when granting three identical pins (top score in midterm quiz), the first student to be announced has received intense applause, while the third was barely applauded – at a distance of seconds. Therefore, the most challenging aspects that need to be managed concerning the offline pins are not the material issues per se (designing, ordering, depositing etc) but the symbolic issue of creating and maintaining their **ritual** dimension.

We have initially assumed that the purpose and functions of this badge architecture are transparent for all participants, students and teachers alike, in virtue of the simplicity and self-explanatory nature of the system, and a shared gaming culture. Subsequent discussions have indicated that this was not the case: the only objective which featured prominently in members' talk was "to motivate students to be more engaged with the course". This is why we have decided to make the architecture more **verbose** – that is, to publish explicit self-descriptions for some of its rationales. This digital loquacity of the system was organized as a hypertext, with increasing layers of details aimed at different publics.

Last but not least, if there is a shared keyword across most objectives, it is **talk**. Badges are designed for conversation: they are alive if students, professors, employers end up discussing them one way or another. Students can contribute to course discussions, can "brag" about their achievements, can mention them in their online presentations; faculty members can talk about them as a noteworthy feature of their course, and as a personal accomplishment. Still, all this talk is only a possibility, until it really happens. The most difficult task of this achievement architecture is **to kindle its conversational infrastructure**.

5 CONCLUSIONS

Badge architectures are an increasingly relevant component of learning experiences. Engineering education is especially inclined towards using achievement-type rewards, due to widespread engagement with the gaming culture. We argue that the conceptual framework for reflecting and evaluating badge architectures relies on two common, but problematic, tropes: that badges are **simple** mechanics added to an activity, and that they operate within the **intrinsic / extrinsic** motivation dichotomy. Instead, we propose that badge architectures can be more productively thought of in light of their **descriptive and creative functions** for the system in which they are implemented. In brief, badges are productive elements: they can generate **maps, portraits, timelines**, and they open up a **meta-system level of activity**. At their best, badge architectures may help participants internalize extrinsic motivations for study and work, and they may open a communication space centered on the experiences and skills that they reward.

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SHORT PAPERS

Development and Evaluation of Case Method Teaching Materials using Manga on Tablet PCs

A Trial with Pointing Type Annotations

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Keywords: Tablet PC, Pointing, Annotation, Manga, Case Method, Teacher Education.

Abstract: The purpose of this research was to develop and evaluate a system that could be used to support university students and graduate school students desiring to become teachers by providing the knowledge and skills necessary for them to provide instructions for scientific experiments; the system involved sharing awareness of issues using easy to use tablet PCs. The system required learners to perform touch operations by pointing at locations with pins of four colors, at which time they became aware of issues within the scenes of the experiments involving the pupils depicted in the manga displayed on the screen. The learners mutually shared the things they noticed using the sharing function. The manga displayed on the screen is a case method learning material, developed for the purpose of educating teachers. It is embedded with a diverse amount of knowledge and skills necessary to become a science teacher, while enabling learners to acquire the observation skills of teachers. The sharing function and the color-sorted frame advancing function of this system were rated positively by the students. Furthermore, learners suggested that the system could be improved by adding a memo function as well as a function for an overall view and for viewing arbitrary pages.

1 INTRODUCTION

Currently, the greatest challenge for teacher education in Japan is nurturing the qualifications and abilities of teachers in order to increase their degree of specialization. The concept of pedagogical content knowledge (PCK) is widely known with regard to the qualifications and abilities of teachers (e.g., Gess-Newsome and Lederman, 1999; Mishra and Koeher, 2006). PCK is quite simply the knowledge that links directly to the abilities and levels of a teacher's specialty. The understanding of knowledge pertaining to experimental tools and educational materials, as well as experimental skills, is essential for teachers, particularly in the field of science education. Teaching materials for teacher education designed to nurture such power of execution, however, are lacking.

Technologies, including information and communication technologies (ICT) and digital content, on the other hand, have been widely implemented in the field of education, right from elementary schools to universities. Tablet PCs, such as iPads and Androids, are starting to become popular as tools for learning, particularly in recent years. Many of the methods employed for such uses are knowledge communication types of multimedia educational materials or drill and tutorial type systems, developed with consideration for individualized support in an environment with simultaneous instructions (e.g., Ostashewski and Reid, 2010; O'Loughlin, 2011).

Each individual learner, however, can handle a tablet PC and communicate with others, as well as share information, regardless of whether they are linked by Bluetooth or are configured into a server-client setup. This is the reason tablet PCs have been utilized as tools to promote sharing and externalizing and building knowledge in learning communities (e.g., Kim et al., 2009; Reid and Ostashewski, 2011).

The biggest feature of tablet PCs, however, is the convenient operations involving touching and gesturing. This aspect must therefore be fully considered when tablet PCs are utilized as tools for learning, through such means as keeping the entry of text to a minimum. A learning system intended for nurturing the practical instructional abilities of teachers who teach science was developed by utilizing the features of tablet PCs, such as touching and gesturing, to create a collaborative learning environment intended for teachers of elementary schools, university students and graduate school students desiring to become teachers.

The specific educational materials utilize manga as a communication tool with the aim of enabling effective interaction with tablet PCs. This is because students can read and interpret manga stories in relatively short periods of time; moreover, it is possible to provide information that is focused on the portions that should be read by the students. This characteristic of manga can be displayed effectively on tablet PCs and awareness of the students can be easily displayed and shared by performing touching or gesturing operations. These educational materials were case method educational materials developed by Daikoku and his associates (2010), which use manga that depicts scenes of learning actually occurring in experiments by pupils. The acquisition of situational decision-making abilities is supported by integrating the learners into the stories as the main characters in charge of solving problems. These case method educational materials were developed and evaluated as paper-based materials and their effectiveness has already been confirmed (e.g., Daikoku et al.,2011).

Learners in the community can use this system to share pins indicating their awareness from images representing scenes from science experiments in their elementary school and their thoughts. The pins represent what the students in the community thought about and what they became aware of.

The idea was to utilize these more effectively on tablet PCs. A system for visualizing and sharing locations, which learners notice in manga educational materials for the case method by inserting annotations through touch operations, was therefore developed and its effectiveness was examined for the purpose of this research.

2 OUTLINE OF SYSTEM

2.1 Development Environment

The development environment for tablet PCs was Adobe Flash CS5.5. It was therefore possible to release publications as applications for iOS and Android, respectively. The development environment on the server side comprised Windows 7 (Professional), Apache 2.2, PHP 5.3 and MySQL 5.5. As long as the same level of service can be provided, it will also be possible to create an environment on other operating systems.

2.2 System Configuration

Figure 1 shows the configuration of this system.

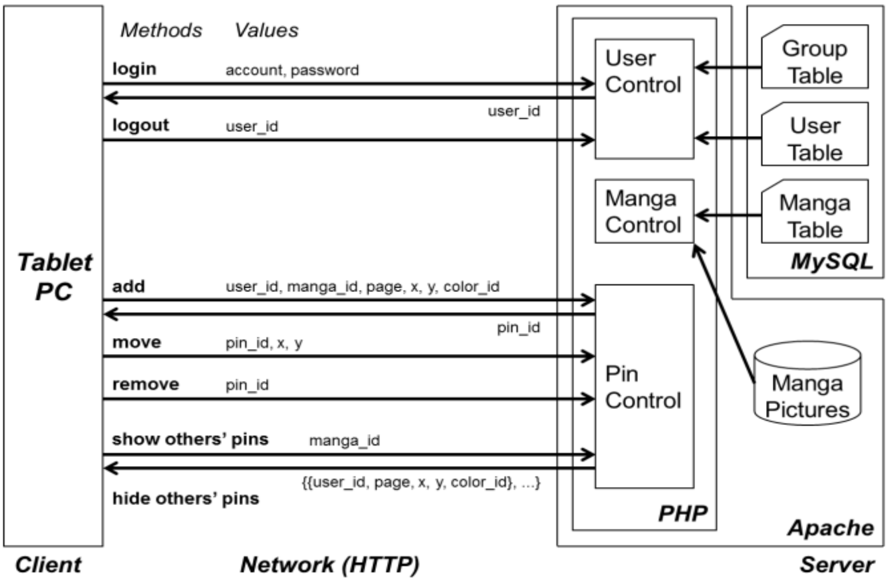

Figure 1 : The configuration of this system.

Although only one tablet PC is depicted here, multiple tablet PCs were actually connected to the server, making it possible to share data, for instance, with placed pins. Once logged into the system, clients are able to browse any arbitrary page of manga and operate a variety of functions, primarily the pin placement function on any arbitrary location in the frames—wherever they feel problems exist. Information of such operations is sent to the server via the network and then stored in the MySQL database via the Control unit on PHP. Once the "show others' pins" command is sent from a tablet PC, the information on all pins placed on the manga being viewed is read from the MySQL database and loaded onto the tablet PC. Those pins are then displayed on the tablet PC. The sharing of pins that represent awareness locations among the learners becomes possible in this manner.

2.3 User Interface and Functions

Figure 2 shows the condition of how locations where individuals have become aware of issues are represented by the positioning of pins using the user interface (for iPads) of this system. The operation section for various functions located in the upper section of the interface is shown in Figure 3.

2.3.1 Pin Placement Function

Pins of four colors, blue, green, yellow, and red, are arranged as shown in Figure 3. These pins are dragged and dropped onto the manga to add annotations. Pins in four colors were developed to allow learners to use them according to their arbitrary observation points. Blue has been assigned to lesson instructions; green, to experimental skills; yellow, to lesson environments; and red, to others for the purpose of facilitating a common understanding on the observation points in our practical implementation.

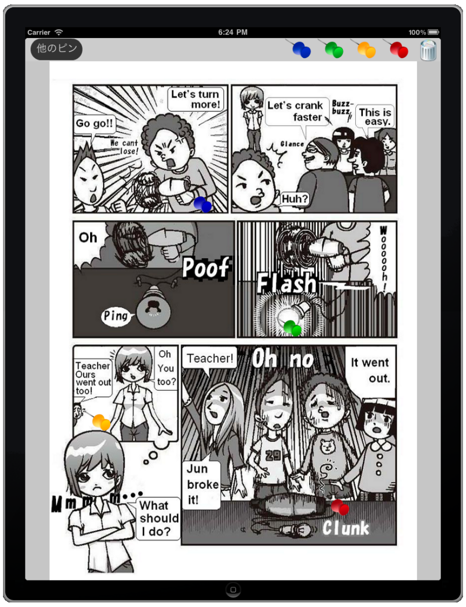

Figure 2: User interface after pin placement.

Assigning such meanings to pins clarifies the observation points that led to the placement of pins on locations.

2.3.2 Pin Relocation and Deletion Functions

Pins that have been placed can be relocated. Furthermore, pins can be dragged and dropped into a trash bin located in the operating section, shown in Figure 3b, when they have to be deleted.

2.3.3 Manga Page Manipulation Function

Users can flip forward through the manga by swiping a page to the right and move backward by swiping pages to the left (Figure 3d). No buttons have been specially set up for these purposes.

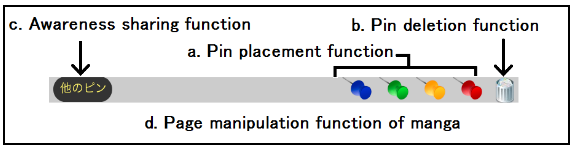

Figure 3: Operating section for various functions.

2.3.4 Awareness Sharing Function

Touching the "Other pins" button, shown in Figure 3c, displays pins placed by other learners on the same page as semi-transparent pins (Figure 4). This operation enables learners to share annotations using pins. Conversational activities can be promoted by focusing on the relocations and colors of pins.

The locations of the focus and their categories can be represented using pins of four colors and shared through touching and gesturing operations of this system, which can be considered to be fully utilizing the conveniences of tablet PCs.

3 EVALUATION OF THE SYSTEM

3.1 Evaluation Subjects and Period

The study involved a total of six subjects from 4 university students and 2 graduate school students

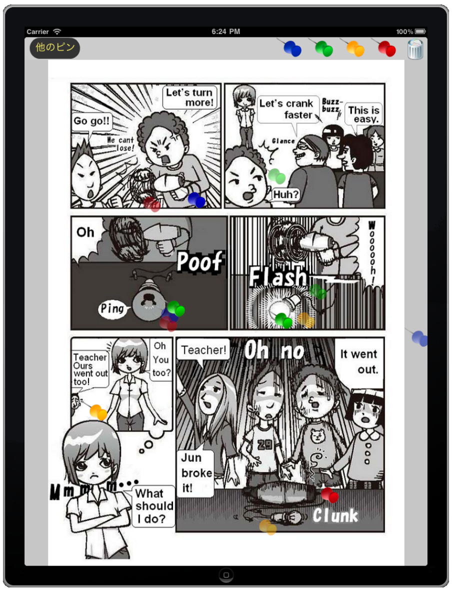

Figure 4: User interface after sharing.

desiring to become teachers, a national university located in Japan. None of the subjects had any experience using this system or the case method educational materials that use manga. The study conducted in October 2012.

3.2 Procedure of the Experiment

Operations were explained to the learners before the relationship between the colors of pins and observation points was explained. They were then instructed to read through the manga once, swiping pages to flip through it. Next, learners were given 10 minutes to perform the task of placing the pins at locations in the frames of the manga where they became aware of issues. Discussions were held by having learners mutually share the pin placements. A discussion that focused on different locations selected for the awareness of issues, as well as how pins of different colors were placed even in the same frames, was held for about 30 minutes. Figure 5 shows the evaluation of the experiment. All the subjects were interviewed immediately after the experiment.

3.3 Procedure of the Survey

An interview survey was conducted in order to clarify the validity of the system, focusing primarily on the functions of the system, from the perspective of the learners. The duration of the interview was about 10 minutes per person. The responses were video-taped and then transcribed.

Figure 5: Evaluation of experiments.

4 RESULTS AND DISCUSSION

The results of the study are discussed from the perspective of the advantages and improvements for learners**.**

4.1 Advantages of the System

The trends of responses pertaining to the advantages of the functions of this system, from the perspective of the learners, are summarized by the following three aspects. They are individually examined, with a typical interview protocol cited in Table 1.

4.1.1 Ease of Sharing Awareness of Issues

Six subjects all cited the ease of sharing pins for indicating awareness of issues. A in Table 1 depicts a typical protocol relating to the ease of becoming aware of the issues indicated by pins in frames. Regarding the use of sharing functions for the awareness of issues, KI, YA, HI, AN, IN, and KE positively evaluated the aspects of ease of gaining knowledge differences in the awareness of issues in frames indicated by pins, as well as differences in observation points. On the other hand, AN cited the benefits of having a comprehensive overview of others' awareness of issues at a glance, which made it possible to improve efficiency in discussions, along with the ease for specifying particular frames.

4.1.2 Color-coded Pins Placed in Frames Facilitated Easy Identification of Observation Points

Two people positively evaluated the color coding of pins placed in frames. B in Table 1 depicts a typical protocol relating to the ease of seeing the observation points, due to the color coding of the pins used in frames. AN and IN both evaluated the clarification of observation points using color-coded pins in frames to be a positive aspect that made it easier to determine the differences in frames.

4.1.3 Several Pins can be Placed on Locations of Concern

Two people evaluated the fact that a lot of pins can be placed on a location positively. C in Table 1 depicts a typical protocol relating to the fact that many pins can easily be placed on locations of concern. AN and IN both positively evaluated the fact there is no limit on the number of pins that can be placed on locations where an awareness of issues exists.

4.2 System Improvements

Trends of the responses pertaining to improvements in the functions provided by this system, from the perspective of learners, are summarized into the following three aspects. They are individually examined, with a typical interview protocol cited in Table 2.

4.2.1 Memo or Sticky Note Function is Desirable

Three people cited the necessity of adding a new memo or sticky note function to the pin placement function of this system. A in Table 2 shows a typical protocol for such a memo or sticky note function. HI and KE both cited the necessity of retaining details of awareness on issues in frames as memos. This can be interpreted as an indication that issues can be forgotten with the current specification of noting observation points using only pins with four color codes.

Table 1: Advantages of this system from the perspective of learners.

A. Ease of sharing

KI: I thought it was very interesting how I could share my observations with the people around me. I noticed how other people placed their pins at locations different from mine or they noticed things different from me and when I became aware of them, I could often figure out what they must have been thinking when they placed their pins, just by looking at those pins.

YA: There were a few places that I overlooked, so I think it was very good.

HI: I thought it was good that I could clearly see how other people used different color codes from mine on the same locations or where others also placed their pins on the same locations as me.

AN: The fact that things can be clearly seen and that the system allows you to see the opinions of other people all at once, I believe, shortens the time of discussion in comparison with ordinary debates. It was good that the details could be pointed out properly and clearly simply by referring to specific pins in particular frames.

IN: It was good because viewpoints and opinions of other people could be seen at a glance and be very easily understood.

KE: When you notice that other people have placed their pins at locations different from yours, you wonder why, which leads you to have a new awareness of issues.

B. Ease of seeing observation points with color-coded pins in frames

AN: Simply put, I think you can become develop a completely different awareness of issues, even in the same frame, by clarifying them using pins, since they are color coded blue, green, yellow, red, and so on.

IN: What I thought was good about the system is that since four colors were available for the pins, even when multiple pins were placed on the same frame, it was clear to see the differences in perspective, which led to the placing of those pins.

C. Ability to place many pins on locations of concern

AN: There is a benefit in the fact that many pins can be used to cover places where concerns exist.

IN: Since pins can be placed many times, it allowed me to place pins at many locations and also allowed other people to place their pins in many places. Thus, it was not about one place or the other on any given page, but we were able to place our pins for a variety of reasons.

* The two alphabetical characters placed in front of the protocols represent the initials of the names of the test subjects. (The same applies hereinafter.)

Table 2: Improvements to this system suggested by learners.

A. Memo or sticky note function

HI: I think it would have been better to have some kind of sticky note, on which you can enter memos, rather than pins. When you have so many pins placed on a frame, you may forget why you placed your own pins, so it would be handy to have a memo when sharing with other people later on.

KE: It would probably be useful if memos could be entered, especially for people who tend to be a bit forgetful.

B. Ability to viewing all pages and select particular pages

HI: It would have been good if we were able to have an overview of all the pages and then select particular pages, but instead we had to flip one page at a time, which made the task quite cumbersome.

KI: I would like a function that makes it possible to view a previous page.

C. Function to change colors of pins.

KE: It would be good if it was possible to select a desired frame in a similar fashion as right clicking on a computer or selecting colors with right click, etc.

IN: When I was performing the task, I actually experienced situations where I thought and did change colors of particular pins; these changes were reflected on my own display but not on my neighbor's display.

4.2.2 Functions for Viewing All Pages and Selecting Particular Pages

Two people mentioned the need to add new functions for viewing pages in their entirety to the system. B in Table 2 shows a typical protocol for adding the option of displaying an overall view of all the pages to the manga page manipulation functions. HI stated that it was cumbersome to flip pages, whereas KI cited the need to view previous pages immediately. Thus, a function that allows users to jump to a page or to open an arbitrary page across the entire file and improve efficiency is needed, since at the present time the page manipulation functions for the manga only allow learners to flip one page at a time.

4.2.3 Function to Facilitate the Changing of Colors of Pins

Two people stated that they would like to be able to change the color of pins while performing their tasks. C in Table 2 shows a typical protocol for changing the colors of pins after placing pins and also while sharing them. KE requested a function that enables the changing of colors instantly whenever a need to do so arises, whereas IN cited that the changing of colors while sharing awareness on the issues should be reflected on the screen shared with other people. This feedback points to poor efficiency of the system, due to the fact that in order to modify the color of a pin, it must first be deleted and a new pin then be placed. Moreover, once sharing starts, it is not possible to alter the colors of the pins in frames.

5 CONCLUSIONS

A system that displays case method educational materials in the form of manga on tablet PCs and allows users to add annotations on the points of observations using pins placed on frames to be shared via a network was developed in this study. The system was evaluated from the perspectives of learners and all test subjects validated the utility of the function for sharing awareness on issues. Furthermore, other features, such as clear indication of points of observations by placing color-coded pins on frames and having an unlimited number of pins that can be placed onto frames, were also positively evaluated.

Suggestions for improvement included requests for additional functions, such as a function for providing an overview of all the pages at a glance and for displaying a particular page, as well as a function for easily changing the colors of the pins placed in frames. We would like to refer to incorporate these opinions by making relevant additions and improvements to the system.

ACKNOWLEDGEMENTS

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Text Mining in Students' Course Evaluations
Relationships between Open-ended Comments and Quantitative Scores

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Keywords: Text Mining, Course Evaluation, Teacher Evaluation, Factor Analysis, Keyphrase Extraction.

Abstract: Extensive research has been done on student evaluations of teachers and courses based on quantitative data from evaluation questionnaires, but little research has examined students' written responses to open-ended questions and their relationships with quantitative scores. This paper analyzes such kind of relationship of a well established course at the Technical University of Denmark using statistical methods. Keyphrase extraction tool was used to find the main topics of students' comments, based on which the qualitative feedback was transformed into quantitative data for further statistical analysis. Application of factor analysis helped to reveal the important issues and the structure of the data hidden in the students' written comments, while regression analysis showed that some of the revealed factors have a significant impact on how students rate a course.

1 INTRODUCTION

Teacher evaluations and overall course quality evaluations, where students submit their feedback about the teacher and the course anonymously at the end of the course or during the course, are widely used in higher education. The results of such evaluations is one of the most common tools used by universities to improve courses for future students and to improve teachers effectiveness (Seldin, 1999; Wright, 2006). At the same time, student ratings is also one of the most controversial and highly-debated measures of course quality. Many have argued that there is no better option that provides the same sort of quantifiable and comparable data on teaching and course effectiveness (Abrami, 2001; McKeachie, 1997).

In addition to analysis of quantitative answers for questions, there is a need for analyzing students' written comments. Many instructors say that they get much more relevant information from students' written comments than they do from the quantitative scores. Teachers can use insights from the ' written feedback to make adjustments to future classes in a more productive way.

Student's written feedback is also of interest for university administration and study board, however it is hard to go trough all the comments from all courses taught at the university every semester. It is more convenient to have a general overview of the main points of student satisfaction and dissatisfaction, extracted from students written feedback.

A tool, that helps to automatically extract important points from open-ended questions from course evaluation, can add important information to the process of analysis and improvement of courses. This study is just an early stage that tries to find the most important patterns in students' written positive and negative feedback for one well established course, at the Technical University of Denmark (DTU) using simple statistical and text-mining tools.

2 LITERATURE

Analysis of open-ended students' comments is problematic, because written comments have no built-in structure. Another challenge is that open-ended questions have much lower response rates than quantitative questions and there are some comments like ”no comments” or ”nothing”, that are unhelpful. On the other hand the open ended nature of a question allows students to focus on what exactly is the most important for them.

Students' written comments have not received as much attention as quantitative data from student evaluations. Lots of studies have been done on validity and reliability of quantitative data for course improvement and on relationship between student ratings and student achievements (Cohen, 1981; Feldman, 1989; Abrami et al., 2007).

Studies on analysis of written comments, that have been published, suggests how written student comments can be organized and analyzed in order to reveal information about aspects of the learning process (Lewis, 2001; Hodges and Stanton, 2007). Most of such studies suggest manual categorization of comments into groups of positive, negative and neutral, or some other kind of grouping, with further investigation of particular factors that reflects students satisfaction or dissatisfaction within each group.

It is quite hard to classify written feedback. Because of it's open-ended nature, the text, that is entered by a student, can range from a few noncritical words such as ”cool teacher” to paragraphs with detailed analysis. In general, students more often write positive comments, rather then negative, and comments tend to be more general rather than specific (Alhija and Fresko, 2009).

Not much research have been done to investigate the relationship between data obtained from the written comments and data obtained from the quantitative part of evaluations. Improvement of computational power and the development of more sophisticated text mining techniques allows for a more sophisticated analysis on teacher and course evaluation data (Romero and Ventura, 2007).

Studies that have looked into relationship between the quantitative data and the students written responses suggest that there is a correlation between the quantitative and written feedback from students (Sheehan and DuPrey, 1999), but such examinations are relatively rare.

3 METHODS

Unstructured data, as students' written feedback, is difficult to process and to analyze. Text mining is the process of deriving information from text, that usually involves the process of structuring the input text, deriving patterns, and finally evaluating and interpreting the output.

Text mining is an interdisciplinary field that draws on information retrieval, data mining, machine learning, statistics, and computational linguistics. It is of importance in scientific disciplines, in which highly specific information is often contained within written text (Manning and Schutze, 1999).

3.1 Term-document Matrix

A lot of the text mining methods are based on construction of a term-document matrix, high-dimensional and sparse mathematical matrix that describes the frequencies of terms that occur in a collection of documents. There are various ways to determine the value that each entry in the matrix should take, one of them is tf-idf.

Term frequency - inverse document frequency (tf-idf), is a numerical value which reflects importance of a word for a document in a collection of documents. The tf-idf value increases proportionally to the number of times a word appears in the document, but with an offset by the frequency of the word in the corpus, which helps to control for the fact that some words are generally more common than others (Salton and Buckley, 1988).

Tf-idf is defined as the product of two statistics: term frequency, the number of times that term occurs in a document devided by the total number of words in the document, and inverse document frequency, a measure of whether the term is common or rare across all documents. It is defined by dividing the total number of documents by the number of documents containing the term, and then taking the logarithm of that ratio.

The tf-idf weight of term t in document d is highest when t occurs many times within a small number of documents, lower when the term occurs fewer times in a document, or occurs in many documents and lowest when the term occurs in almost all documents of a collection.

3.2 Key Term Extraction

Extraction of keyphrases is a natural language processing task for collecting the most meaningful words and phrases from the document. It helps to summarize the content of a document in a list of terms and phrases. Automatic keyphrase extraction can be used as a ground for other more sophisticated text-mining methods.

In this study, the Likey keyphrase extraction method (Paukkeri and Honkela, 2010) is used. Likey is an extension of Damerau's relative frequencies method (Damerau, 1993). It is a simple language-independent method (the only language-specific component is a reference corpora). According to the method, a *Likey ratio* (1) is assigned to each phrase (Paukkeri et al., 2008).

$$L(p,d) = \frac{rank_d(p)}{rank_r(p)} \tag{1}$$

where $rank_d(p)$ is the rank value of phrase p in document d and $rank_r(p)$ is the rank value of phrase p in the reference corpus. The rank values are calculated according to the frequencies of words of the same length n. The ratios are sorted in increasing order and the phrases with the lowest ratios are selected.

3.3 Statistical Methods

3.3.1 Factor Analysis

Multivariate data often include a large number of measured variables, and often those variables ”overlap” in the sense that groups of them may be dependent. In statistics, factor analysis is one of the most popular methods used to uncover the latent structure of a set of variables. This method helps to reduce the attribute space from a large number of variables to a smaller number of unobserved (latent) factors.

Factor analysis searches for joint variations in response to unobserved latent variables. The observed variables are modeled as linear combinations of the potential factors, plus ”error” term. The coefficients in a linear combination are called factor loadings.

Sometimes, the estimated loadings from a factor analysis model can give a large weight on several factors for some of the observed variables, making it difficult to interpret what those factors represent. The varimax rotation is the most commonly used criterion for orthogonal rotation, that helps to simplify the structure and ease interpretation of the resulting factors (Hair et al., 2006).

3.3.2 Logistic Regression

Logistic regression is a type of regression analysis used in statistics for predicting the outcome of a categorical dependent variable based on one or more usually continuous predictor variables. In cases where the dependent variable consists of more than two categories which can be ordered in a meaningful way, ordered logistic regression should be used.

The relationship between a categorical dependent variable and independent variables is measured, by converting the dependent variable to probability scores. The model only applies to data that meet the proportional odds assumption, that the relationship between any two pairs of outcome groups is statistically the same. The model cannot be consistently estimated using ordinary least squares; it is usually estimated using maximum likelihood (Greene, 2006).

4 DATA DESCRIPTION

At the Technical University of Denmark (DTU), as in many other universities around the world, students regularly evaluate courses. At DTU students fill final-evaluation web-forms on the university’s intranet one week before the final week of the course. It is not mandatory to fill out the course evaluation. The evaluation form consist of tree parts: Form A contains specific quantitative questions about the course (Table 1), Form B contains specific quantitative questions about the teacher and Form C gives the possibility of more qualitative answers divided in 3 groups: What went well?; What did not go so well?; Suggestions for changes.

Table 1: Questions in Form A.

A.1.1	I think I am learning a lot in this course
A.1.2	I think the teaching method encourages my active participation
A.1.3	I think the teaching material is good
A.1.4	I think that throughout the course, the teacher has clearly communicated to me where I stand academically
A.1.5	I think the teacher creates good continuity between the different teaching activities
A.1.6	5 points is equivalent to 9 hours per week. I think my performance during the course is
A.1.7	I think the course description’s prerequisites are
A.1.8	In general, I think this is a good course

The students rate the quantitative questions on a 5 point Likert scale (Likert, 1932) from 5 to 1, where 5 means that the student strongly agrees with the given statement and 1 means that the student strongly disagrees. For question A.1.6, 5 corresponds to ”much less” and 1 to ”much more”, while for A.1.7, 5 corresponds to ”too low” and 1 to ”too high”. These questions where decoded in such a way that 5 corresponds to best option and 1 corresponds tho the worst.

For this paper data from a Mathematics for Engineers course was analyzed. This is a bachelor 5-ECTS points introductory level course that is available in both spring and fall semesters. The course is well established with almost the same structure over the last 5 years, thus it is large enough to collect a sufficient number of comments to perform text analysis.

Table 2 presents the response rates on the course from fall 2007 to spring 2012. The number of students that followed the course during spring semesters is approximatively half of that for fall semesters. The course is mandatory for students who want to enter a Master program at DTU. According to the program the most convenient is to take this course in the fall semester of the second year of education. A part of the spring semester students are those who failed the course in the fall semester. The response rates are lower for spring semesters (33-49%), than for fall semesters (41-62%).

There are more students, who write positive comments than those who write negative. However the

Table 2: Number of comments.

semester	n.s.	n.e.	r.r..	n.p.c.	n.n.c.	n.o.s.
spring 2012	251	85	33,86%	32	28	30
fall 2011	494	239	48,38%	78	60	70
spring 2011	262	93	35,50%	30	41	37
fall 2010	520	212	40,77%	60	46	46
spring 2010	260	101	38,85%	35	25	29
fall 2009	545	337	61,83%	153	91	98
spring 2009	223	73	32,74%	31	22	21
fall 2008	517	290	56,09%	93	71	83
spring 2008	225	111	49,33%	37	21	17
fall 2007	566	326	57,60%	119	58	68
total	3863	1867	48,33%	668	463	499

n.s. - number of students registered for the course

n.e. - number of students that answered some question of evaluation

r.r. - response rate

n.p.c. - number of positive comments

n.n.c - number of negative comments

n.o.s. - number of suggestions for changes

average length of the negative comments (35 words) is 10 words larger than the average length of possitive comments(26 words) and suggestions (25 words).

Figure 1 shows a change in the average student rating of the course over time. The students satisfaction of the course dropped down by approximately half a point on a Likert scale in spring 2011 for all of the questions except A.1.7. (course prerequisites).

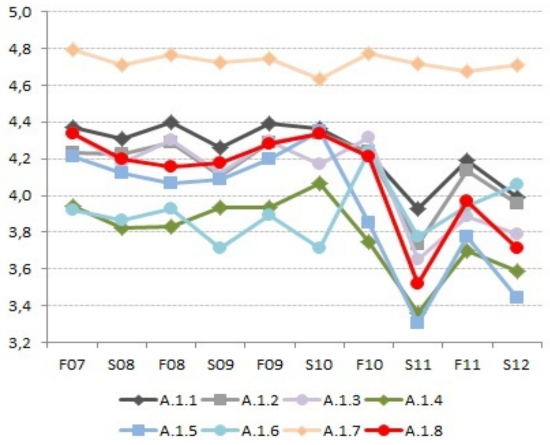

Figure 1: Change in average quantitative ratings over time.

The course is well-established: the curriculum, the book and the structure of the course were the same during last years. However one of the main teachers changed in spring 2011. This caused a drop in course evaluation, since the teacher was not experienced in teaching introductory-level courses and had higher expectations to the students. The results of course and teacher evaluations were analyzed and changes in teaching style were made for the next semesters.

The general objectives of the course are to provide participants with tools to solve differential equations and systems of differential equations. Some mention mathematical issues related to the course topics.

5 RESULTS

5.1 Term Extraction

The length of student comments on the course under consideration ranges from 1 word to 180 words. Even large comments are not long enough to perform keyphrase extraction solely on them. The keyphrase extraction process was done in the following way:

1. All comments for each semester were collected in 3 documents corresponding to the 3 open-ended questions in the questionnaire. It resulted in 10 documents for each type of comments.
2. In order to apply the Likey method, the documents were preprocessed. English comments and punctuation were removed, numbers were replaced with *num* tags and teacher and teaching assistants names with *teachername* and *taname* tags.
3. From each document 50 one-grams (keyphrases that contain just one term - key term) were extracted. These key-terms show the main topics of the students' comments in each semester.
4. Obtained term-lists were stemmed using the Snowball stemmer (http://snowball.tartarus.org/) and irrelevant terms, like slang, were removed.
5. The stemmed term-lists were combined into 3 general term-lists that represent the main topics of comments through the last 5 years.

This procedure resulted in: a positive comments term-list with 142 terms; a negative comments term-list with 199 terms; a term-list of 190 terms representing main topics of suggestions for improvements.

It is not surprising that the negative comments term-list is much longer than the term-list from the positive comments. Students tend to write positive comments that are more general, but in negative comments they tend to write about specific issues they were not satisfied with.

The Danish Europarl corpus, a corpus that consists of the proceedings of the European Parliament from 1996 to present and covers eleven official languages of the European Union (Koehn, 2005), was used as the reference corpus to perform Likey.

Based on these 3 term-lists 3 corresponding term-document matrices where created. Each row correspond to a single comment in the collection of comments over 10 semesters, each column corresponds to a key term and each entry is a tf-idf weight of a key term in the collection of comments. These matrices were used for the further analysis.

5.2 Factor Analysis

The statistical analysis was done separately for two groups of comments, positive and negative feedbacks. Suggestion comments are expected to correlate a lot with negative comments.

Factor analysis of the term-document matrices was done to reveal the underlying structure of the written feedback from the students. The number of factors, that should be used, is a tricky question, as there is no prior knowledge on the possible number of factors. The Kaiser rule to define the optimal number of factors, that states that the number of factors to be extracted should be equal to the number of factors having variance greater than 1.0, suggests 50 factors for the dataset of positive comments, while randomization method suggests that around 40 factors should be extracted. Another important issue is interpretability of the factors, therefore it was decided to extract 10 factors for each group of comments.

Factor analysis can also be used for outlier detection (Hodge and Austin, 2004). Observations with factor scores, the scores of each case (comment) on each factor (column), greater then 3 in absolute value were considered as outliers.

Figure 2 shows the difference of factor scores distribution for the first and the second factor before and after outlier removal for positive comments dataset. At least 3 observations that are different from others.

One of the most illustrative examples of an outlier is a "positive" comment from a student, who had a long break in studying: *"I had a longer break from the studies… when I stopped at the time it was among other things because of this course which frustrated me a lot since… it is nice that this has improved…"*

This comment really differs from the others in the style it is written. Other examples of outliers are comments that mentioned a specific issue that is not mentioned by any other respondents, or comments where a specific issue, for example the "Maple" programming language, is mentioned many times. In total 59 observations were removed from the positive comments data and factor analysis was performed again.

In order to increase interpretability and simplify the factor structure the varimax rotation of the factor reference axes, that aims to have as many zero factor loadings as possible, was done.

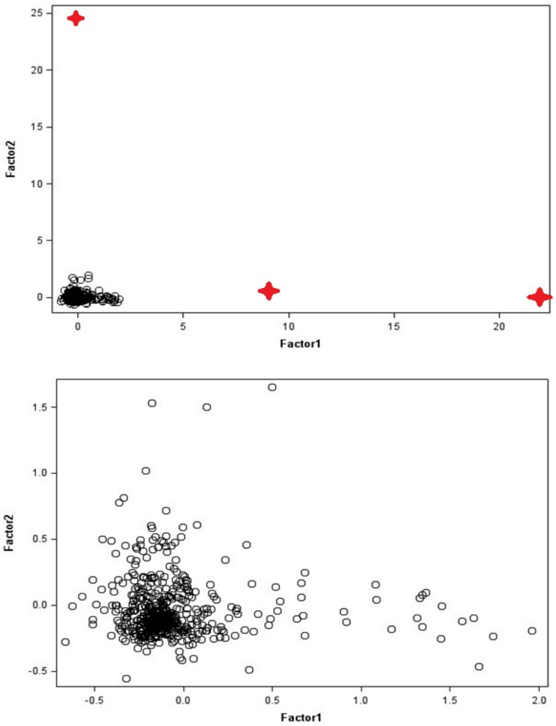

Figure 2: Factor1 scores vs. Factor2 scores for positive comments before and after outlier removal.

Table 3 shows the most important variables (factor weight higher than 0.25 in absolute value) in each factor for the positive comments. The presented terms are translated from danish. Terms with are presented.

Extracted factors can be interpreted as:

- Factor1 - *overall course quality in relation to other courses*
- Factor2 - *good teacher qualities.*
- Factor3 - *weekly home assignments* - students were motivated to spend extra hours at home to understand the material.
- Factor4 - *good textbook quality*
- Factor5 - *blackboard teaching performed by lecturer/ presentation of material*
- Factor6 - *teaching assistant (TA's) communication during exercise classes*
- Factor7 - *weekly question sessions* - question sessions are an extra hours, where students can ask question regarding the course material.
- Factor8 - *teaching during exercise classes.*
- Factor9 - reflects 2 things: *possibility to follow the course twice a week* and *appropriate level of home assignments.*

Table 3: Rotated factor pattern for positive comments.

Factor1		Factor2		Factor3		Factor4		Factor5	
keyterm	cor	keyterm	cor	keyterm	cor	keyterm	cor	keyterm	cor
educational	0,60	skilled	0,44	time	0,56	general	0,48	example	0,51
course	0,50	exciting	0,44	assignments	0,47	view	0,45	blackboard	0,40
control	0,41	professional	0,44	additional	0,47	nice	0,45	*teachername*	0,39
DTU	0,36	teacher	0,43	week	0,40	read	0,42	topic	0,39
less	0,36	mathematics	0,39	good	0,36	ok	0,38	go through	0,33
lecturer	0,35	communicate	0,38	home	0,36	course	0,38	really/very	0,32
most	0,31	fun	0,33	idea	0,32	little	0,32	theory	0,29
amount	0,27	*teachername*	0,31	division	0,30	textbook	0,26	statement	0,27
curriculum	0,26	enormous	0,29	understand	0,28	really	0,30	because	0,27
				teachername	-0,30	Maple	0,27	do	0,26
Factor6		**Factor7**		**Factor8**		**Factor9**		**Factor10**	
keyterm	cor	keyterm	cor	keyterm	cor	keyterm	cor	keyterm	cor
TA	0,63	question session	0,68	lecture	0,36	Monday	0,40	time	0,50
taname	0,59	Tuesday	0,43	really/very	0,35	class	0,36	whole	0,49
good	0,57	week	0,43	exercise	0,33	Thursday	0,34	function/work	0,41
communicate	0,28	teaching material	0,36	good	0,33	great	0,33	students	0,35
very	0,27	pause	0,34	function/work	0,31	amount	-0,27	papershow	0,32
exercises	0,25	course	0,33	material	0,28	home assign.	-0,27	fun	0,25
		fine	0,33	data bar	-0,33	home work	-0,31		
		nice	0,30	nice	-0,38	appropriate	-0,32		
		weekly	0,29	Maple	-0,39	complexity	-0,38		

- Factor10 - *having a good time being a student at the course.*

For the analysis of the negative comments the same outlier removal procedure as for the positive comments was used. It resulted in removing 35 of the negative comments.

Table 4 shows the most important terms in each factor, for the negative comments. The factors can be interpreted as follows:

- Factor1 - *Maple as a tool to solve exercises.*
- Factor2 - *English speaking teaching assistants* - students pointed out that it was harder for them to write assignments in English and/or to communicate with English speaking teacher assistants.
- Factor3 - dissatisfaction with *usage of textbook* - many students argued that examples presented in the class were taken directly from the book.
- Factor4 - *examples to support statements* - some students argue that it was hard to understand some mathematical subjects without examples.
- Factor5 - *not enough TAs for exercise hours*
- Factor6 - *grading of home assignments* - some students complained that TA's grade home assignments differently.
- Factor7 - *frustrating course* - students, that follow the course are very diverse by their background. For some of them the course is really frustrating.
- Factor8 - *project workload* - the course has 2 projects about application of the tools, learned during the course, to the real world problems.
- Factor9 - *last project* - there were complaints that the last project is much harder than the previous.
- Factor10 - *course organization issues: classroom, lecture room and their position on campus.*

5.3 Regression Analysis

In order to investigate the relationship between the quantitative scores and the qualitative feedback an ordinal logistic regression model was used. Students satisfaction and dissatisfaction points can vary in different semesters, therefore it was decided to investigate which factors were important in which semesters. The number of observations in spring semesters (25-30 comments) is not enough to perform multivariate analysis. Therefore, univariate logistic regression was used for each semester to investigate whether there is an impact of each particular factor on how students rate the course. Question A.1.8 (overall course quality) was used as the response variable.

Table 5 shows which positive factors have a significant impact on the way students rate the course. There were no factors, that had a significant impact on the overall course score in spring 2011, the semester

Table 4: Rotated factor pattern for negative comments.

Factor1		Factor2		Factor3		Factor4		Factor5	
keyterm	cor	keyterm	cor	keyterm	cor	keyterm	cor	keyterm	cor
Maple	0,70	course	0,61	explain	0,61	teacher	0,36	help	0,60
tool	0,66	englishspeaking	0,49	book	0,56	statement	0,36	teacher	0,59
pity	0,57	think	0,47	stand	0,54	students	0,33	nature	0,57
solve	0,48	TA	0,40	convergence	0,45	better	0,32	often	0,43
possibility	0,41	should	0,39	new	0,41	example	0,31	exercise	0,39
convergence	0,38	understand	0,37	material	0,39	works	0,26	*taname*	0,36
exercise	0,38	mathematical	0,36	fully	0,36	similar	0,26	solution	0,34
whole	0,33	DTU	0,31	example	0,34	subjects	-0,28	more	0,31
give	0,32	really	0,30	poor	0,32	fully	-0,32	hand	0,30
follow	0,30	whole	0,29	read	0,30			difficult	0,29
exam	0,29	Fourier series	0,27	*teachername*	0,28			example	0,27
		used	0,29	lecturing	0,26				
Factor6		**Factor7**		**Factor8**		**Factor9**		**Factor10**	
keyterm	cor	keyterm	cor	keyterm	cor	keyterm	cor	keyterm	cor
TA	0,49	frustrating	0,48	used	0,49	harder	0,71	room	0,45
grade	0,44	avoid	0,45	difficult	0,45	go through	0,53	campus	0,44
higher	0,42	though	0,44	derivation	0,39	projects	0,51	group work	0,42
difference	0,36	course	0,43	view	0,38	bad	0,43	one	0,38
assignment	0,34	curriculum	0,38	workload	0,36	teaching	0,39	education	0,31
submit	0,33	review	0,38	read	0,34	works	0,39	count	0,31
though	0,32	go through	0,31	project task	0,31	semester	0,38	opposite	0,31
simple	0,27	need	0,31	too much	0,30	away	0,34	annoying	0,29
example	0,27	mathematics	0,31	points	0,30	very	0,32	problem solving	0,29
whole	-0,28	things	0,30	week	0,30	week	0,32	held	0,27
Fourier series	-0,33	start	0,28	good	0,27	assignments	0,28	closer	0,26
understand	-0,34	enormous	0,27	time	0,25			building	0,26
mathematics	-0,39	higher	0,25	very	0,29			mathematics	-0,27

Table 5: significance of factors in univariate ordinal logistic regression for question A.1.8 (overall course quality) vs. factors extracted from positive comments.

	F07	S08	F08	S09	F09	S10	F10	S11	F11	S12
F1										
F2									**	
F3	**								*	
F4									**	
F5		**								
F6			**	*						
F7										
F8										
F9			*							
F10					*		*		**	

* - significant at 10% significance level

** - significant at 5% significance level

when there was a drop in students satisfaction scores (Figure 1). However, the next semester four factors: factor2 (teacher qualities), factor3 (weekly home assignment), factor4 (textbook quality) and factor10 (having a good time being a student at the course) had a significant impact on overall rating of the course. It can imply that teachers reacted on results of evaluation and made changes in the course and teaching.

Table 6 shows which of the negative factors had significant impact on the way students rate the course. For the spring 2011 semester three negative factors: factor1 (Maple as a tool to solve exercises), factor5 (not enough TAs for exercise hours) and factor9 (last project) had a significant impact. It should be noted that the next semester (fall 2011) none of the negative factors were significant.

Spring semesters tend to have lower rating than preceding and subsequent fall semesters (figure 1). A similar pattern is observed in the analysis of impact of negative factors on overall course satisfaction: None of the negative factors had a significant impact in fall semesters, except fall 2009. Factor9 (last project) appeared to have a significant impact on overall course satisfaction score in 4 out of 10 semesters. In spring 2011, the new teacher changed the second project completely, but the problem is not only in complexity of the project but also in its placement in the busiest time of the semester, close to the exams period.

Univariate analysis showed that different factors

Table 6: Significance of factors in univariate ordinal logistic regression for question A.1.8 (overall course quality) vs. factors extracted from negative comments.

	F07	S08	F08	S09	F09	S10	F10	S11	F11	S12
F1								*		
F2					**	*				*
F3										
F4		**								
F5								**		**
F6				*						
F7		**				*				
F8		*			**					
F9		*			**			**		*
F10										

* - significant at 10% significance level

** - significant at 5% significance level

are correlated with the overall course quality score in different semesters. It is not surprising, since each year a new group of students follows the course, teaching assistants are almost always new and teachers can also make changes from semester to semester.

In order to analyze the relationships between the students written feedback and other more specific quantitative evaluations of the course, multivariate logistic regression analysis was used, controlling for year and semester.

Table 7 shows which factors, extracted from the positive comments, had a significant impact on the different quantitative evaluation scores of the particular course characteristics (evaluation form A).

Fall semester students, who wrote positive feedback, rated questions A.1.3 (teaching material) and A.1.6 (workload) significantly different from spring semester students.

For the overall measure of satisfaction with the course (A.1.8) only one positive factor - factor5 (presentation of material) had a significant impact, controlling for the semester and year of teaching. There was no factor that had an impact on A.1.4 (feedback from teacher) quantitative score.

For the question A1.1 (learning a lot) 3 factors: factor1 (overall course quality compared to other courses), factor4 (textbook) and factor5 (presentation of material) had a significant impact. Many students appreciate blackboard derivations of theorems and mathematical statements. The book contains illustrative examples, that helps to understand the theory.

Factor1 (overall course quality compared to other courses) together with factor6 (teaching assistant communication) had a significant impact on how students evaluated the teaching method (A.1.2.). It supports the common opinion that teaching assistants play an important role. It is also supported by the fact that factor6 together with factor3 (home assignments) had a significant impact on how students evaluated the teaching method (A.1.3).

Table 7: Significance of factors in multivariate logistic regressions for course specific questions (Form A) vs. factors extracted from positive comments.

Factor	A.1.1	A.1.2	A.1.3	A.1.4	A.1.5	A.1.6	A.1.7	A.1.8
F1	**	**			*			
F2					**		*	
F3			*					
F4	*					**	**	
F5	*							**
F6		**	*					
F7								
F8					**			
F9						**		
F10								
sem(F)			*			**		
y07				**	***		*	*
y08	*							
y09	*		**		**			**
y10					**			
y11	**		***		**			**

* - significant at 10% significance level

** - significant at 5% significance level

*** - significant at 1% significance level

There are 3 factors that had a significant effect on how students rate the continuity between the different teaching activities (A.1.5): factor1 (overall course quality compared to other courses), factor2 (teacher qualities) and factor8 (teaching during exercise classes). The year, the course is performed, also has a significant impact on A.1.5 score. It illustrates the fact that teachers of the course are constantly working on improvements of the teaching methods.

For the evaluation of course workload (A.1.6) high textbook quality (factor4) and complexity of home assignments (factor9) had a significant impact, while prerequisites (A.1.7) teacher qualities (factor2) and high textbook quality (factor4) were important.

Table 8 shows which factors, extracted from the negative comments, had a significant impact on the different quantitative scores of course characteristics.

For the overall course quality score (A.1.8), two negative factors appeared to be significant: factor4 (examples to supplement mathematic statements) at 10% significance level and factor7 (frustrating course) at 5% significance level.

Factor1 (Maple) and factor2 (English speaking TAs) appeared to have no significant impact on evaluation of any of the course specific characteristics, when controlling for the time the course were taken.

Factor3 (usage of textbook) is the only negative factor that had a significant (10%) impact on how stu-

Table 8: Significance of factors in multivariate logistic regressions for course specific questions (FormA) vs. factors extracted from negative comments.

Factor	A.1.1	A.1.2	A.1.3	A.1.4	A.1.5	A.1.6	A.1.7	A.1.8
F1								
F2								
F3		**		***	*			
F4						**	**	*
F5			***					
F6	*	*						
F7	**	*	**	*				**
F8						***		
F9		*						
F10		*						
sem(F)								
y07					**			
y08				**				
y09	**	*	*	**	**	*		**
y10			*		**			
y11	*		***		**			**

* - significant at 10% significance level

** - significant at 5% significance level

*** - significant at 1% significance level

dents evaluate different teaching activities (A.1.5). It also had a strongly significant impact on A.1.4 (feedback from teacher), together with general frustration (factor7). Some of the students complained that examples on the lectures are taken directly from the book, while for others it made reading of the textbook was an easy repetition of the lectures. Question A.1.5 is also rated differently in different years, that illustrates teacher's constant work on improvement of teaching methods.

Factor5 (not enough teaching assistants) had a significant effect only on how students evaluate the teaching method (A.1.3) together with factor7 (frustrating course). In spring 2012 teachers tried to form groups for exercise sessions according to students study lines, to make groups more uniform. But so far it does not have any effect.

For quantitative evaluation scores on question A1.1 (learning a lot) factor6 (grading of home assignments) and factor7 (frustrating course) have a significant impact. Factor8 (project workload) had a significant effect only on how students evaluate the course workload (A.1.6) together with factor4 (examples to support statements).

For the rating of teaching method (A.1.2.) 5 negative factors had a significant effect: factor3 (usage of textbook), factor6 (grading of home assignments), factor7 (frustrating course), factor9 (last project) and factor10 (course organization issues). The last two had an effect only on teaching method evaluation. Evaluation of course prerequisites (A.1.7) is significantly effected only by one negative factor - factor4 (examples to supplement mathematic statements).

To summarize, factors, extracted from the negative comments, had more significant impact on how students quantitatively evaluate different course qualities, than factors extracted from positive comments. The year, the course is taken, also had a significant effect on rating of different course qualities.

6 DISCUSSION

The present study is a first step of analysis of relationships between the quantitative and qualitative parts of course evaluation. Further investigations should include analysis of the relationship between the comments and questions the teacher satisfaction questionnaire. It is often reflected in comments, that teachers and teacher assistants play an important role in students satisfaction or dissatisfaction with a course.

Diversity of the students is also an interesting factor that should be taken into account for in future research, in order to investigate whether student specific characteristics such as age, gender, years of education, study line, etc have relationship with the way students evaluate teachers and courses. The diversity of the students backgrounds, ranging from mathematical engineering students, to design and innovation students, may also influence on the high dimensionality of the factorial pattern. Thus it would be of interest to adjust for the student background or to preprocess the data by clustering students.

Regarding the text-mining method used in the analysis, one of the drawbacks is that reference the corpus used in the Likey key phrase extraction is a corpus of very formal language of the European Parliament documentation, while student written comments are usually informal, tend to have some slang phrases and have a lot of course specific technical terms, that get higher weight than other terms. Another thing is that the Likey method is a purely statistical tool, it does not take synonyms into account. Usage of a more sophisticated main topic extraction tool can improve the results.

7 CONCLUSIONS

The work makes an analysis of questionnaire data from student-course evaluations from, in particularly the analysis of text from open-ended students comments ant their connection to the quantitative scores.

It was found that factor analysis can help to find comments that are outliers, i.e. really differs from the other in the style it is written or comments about some specific issue that is not mentioned by any other respondent. Furthermore, this method helps to find and summarize the most important points of students satisfaction or dissatisfaction.

It was shown that there is a relationships between some of the factors, extracted from positive and from negative comments, and students' overall satisfaction with the course, and that this relationship changes with the time. It was also shown that different factors have an impact on rating of different course characteristics.

In order to make better responses on students dissatisfaction points and improve courses for the future students, a deeper analysis than just averaging the quantitative data from student evaluation, should be done. Examining the students open-ended feedback from evaluation can help to reveal patterns that can, if properly read, be used to improve courses and teaching quality for future students.

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What Makes an LMS Effective

A Synthesis of Current Literature

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Keywords: Learning Management Systems (LMS), e-Learning, Higher Education, e-Learning Evaluation Framework.

Abstract: There is a growing number of organizations and universities now utilising e-learning practices in their teaching and learning programs. These systems have allowed for knowledge sharing and provide opportunities for users to have access to learning materials regardless of time and place. However, while the uptake of these systems is quite high, there is little research into the effectiveness of such systems, particularly in higher education. This paper investigates the methods that are used to study the effectiveness of e-learning systems and the factors that are critical for the success of a learning management system (LMS). Five major success categories are identified in this study and explained in depth. These are the teacher, student, LMS design, learning materials and external support.

1 INTRODUCTION

Providing an environment for e-learning (electronic learning) and more recently the notion of blended learning in the Higher Education sector has increased the need for these institutions to invest in learning management systems (LMS) to support teaching and learning. This can be viewed as an attempt to be more competitive by attracting a larger market share of students (Turner and Stylianou, 2004). At first, e-learning systems were mostly used to provide external and distance education modalities and to offer more flexibility for external students (Mason, 2006; Allen and Seaman, 2007). However, e-learning has been considered an essential part of the teaching and learning process for many Higher Education Institutions (HEI) and many of these institutions are further adopting a combination of face-to-face (F2F) learning and e-learning (Keengwe and Kidd, 2010; Palloff and Pratt, 2001), which is referred to as blended learning. Rapidly growing developments in information and communications technologies (ICT) provide an opportunity for students to learn in a more flexible environment where access to learning materials and resources is available at all times regardless of the time and place.

However, many users stop using virtual learning tools such as those embedded within an LMS after first practices (Sun et al., 2008). The continued use of the available tools is not high (Chiu et al., 2007) and the discontinuation of e-learning tools after the first adoption, occurs frequently. While initial adoption is an important success factor of using an e-learning system, continuous use is still required to achieve tangible success. Initial e-learning adoption and continued use of LMS tools are two significant concerns in this area.

In an attempt to further explore the LMS critical success factors, this paper reviews and synthesizes different approaches that have been used to study the effectiveness of e-learning systems and discusses the significant factors that help an LMS to be used most efficiently.

2 APPLYING A FRAMEWORK

In analysing and understanding the effectiveness of a particular system frameworks or models are often developed and applied to a body of work. It is within this context that computer human interaction, self regulated learning, collaborative learning, and e-learning acceptance studies, can aid in a deeper understanding of the critical issues that entice users to actively contribute within virtual learning environments. To study the behaviour of LMS users, an overview of seven of the most relevant studies is presented in this section.

2.1 Technology Acceptance Model

The technology acceptance model (TAM) is a framework that has been applied in many technology adoption studies. Its focus is to predict and assess user willingness to accept technology. TAM investigates the relationships between perceived ease of use (PEU), perceived usefulness (PU), and attitudes and intention in adoption. User perception and attitudes toward the system is influenced by both these factors.

This framework can be used as a tool to predict learning satisfaction in virtual learning environments and show the perceived ease of use and perceived usefulness of the LMS that significantly affects student satisfaction (Pituch and Lee, 2006). The application of TAM in relation to LMS's identifies the *perceived ease of use* in student perception of using an e-learning system and the *perceived usefulness* in the perception of the learning enhancement level as a result of the adoption of the system. Perceived usefulness has more impact on intention to e-learning adoption than perceived ease of use which means if students find e-learning objects difficult to use they will rate them as less useful.

2.2 Unified Theory of Acceptance and use of Technology

Venkatesh and Davis (2000) extended the TAM framework and introduced cognitive instrumental processes and social influence as effective factors on perceived usefulness and usage intention and as a result introduced the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh and Davies, 2000). This framework was based on the findings of eight models in Information System (IS) adoption area. It hypothesized three factors that directly predict the intention to use an invention which are:

- *Effort expectancy* or perceived ease of use
- *Performance expectancy* or short term perceived usefulness and
- *Social influence*

It also argues that intention and facilitating conditions were direct predictors of usage behaviour.

2.3 Perceptions of Innovation Characteristics

The Perceptions of Innovation Characteristics (PCI) is yet another model that can be applied in e-learning acceptance studies. This model explains the key innovation attributes that impact on the user acceptance. Critical innovation attributes identified in this model are (Rogers, 1995):

- *Compatibility* which refers to the degree a system is consistent with the learner current requirements, values and previous experiences
- *Trialability* which specifies the user perception of a chance to try the system prior to using it on commitment
- *Relative advantage* which is the level of enhancement a system offers in comparison to previous tools for accomplishing the same task
- *Complexity* which is the level of perceived complexity to learn and use the system
- *Observability* which shows the result visibility of adopting the system

Moore and Benbasat (1991) extended the model to seven constructs including:

- *Compatibility*
- *Trialability*
- *Relative advantage*
- *Ease of use*
- *Result demonstrability* which explains how much the outcomes of using the system are tangible
- *Visibility* which is defined as "the extent to which potential adaptors see the innovation as being visible in the adoption context" and finally
- *Image* which is the feeling that using a system can enhance user social status

2.4 Expectation Confirmation Model

Expectation Confirmation Model (ECM) is a framework that has been applied to study the intention to continue using innovations. This model defines five constructs to explain the consumers level of satisfaction (Oliver, 1980). These steps are:

1. Customers form a preliminary expectation of a particular service or product before purchasing it.
2. Then they accept and make use of that service or product.
3. After a period of first consumption, users form conceptions about the service or product efficiency.
4. Then, consumers determine the level of confirmation of expectations by comparing their perceptions of the service or product performance with their initial expectation. Accordingly, based on the confirmation level, a dissatisfaction or satisfaction feeling is formed.
5. Finally, satisfied users decide to continue using the service or product in the future, whereas dissatisfied consumers stop its later use.

Marketing studies have indicated that consumer level of satisfaction is the main reason to repurchase intention (Szymanski and Henard, 2001). Bhattacherjee suggested to apply ECM in IT acceptance and continued use intention because of the similarity between the user intention to keep using IT products and the consumer intention to repurchase a service or product (Bhattacherjee, 2001). This model hypothesizes that a user decision to continue using Information technology is affected by three factors:

- *Satisfaction*
- *Expectations confirmation* and
- *Post-acceptance expectations*

2.5 Flow Experience Theory

Flow experience theory is a tool that can be used to explain the e-learning adoption. This theory explains the holistic experience that individuals perceive when they are totally engaged in performing a task (Csikszentmihalyi, 1997). In this case, people become so involved in their ongoing activities that they are unable to identify any variation in their surroundings. From the perspective of motivating people to use information technology, Flow experience can be considered as an intrinsic motivation construct in comparison with perceived usefulness, which reflects user extrinsic incentive (Lee, 2010). Its different constructs such as:

- *Concentration and focus* (Lee, 2010), (Li and Browne, 2006)
- *Enjoyment* (Lee, 2010),
- *Attention*
- *Control*
- *Curiosity*

are variables that have been used to measure Flow experience.

2.6 Theory of Planned Behaviour

The Theory of Planned Behaviour (TPB) is also a framework that can be applied in e-learning acceptance studies. Based on this model, the factors that influence behavioural intention are (Ajzen, 1991):

- *Perceived behavioural control* which refers to the availability of required skills and resources as well as the user perception of the necessity of getting the results.
- *Subjective norm* which reflects the perceived social demands to show the behaviour and is related to social normative beliefs about the expectation and
- *Behavioural attitude* which refers to how favourite a person evaluates the behaviour

A number of studies have examined these three variables and found them valid to explain a persons decision to use IT (Liao et al., 1999). Applying TPB to the e-learning field, perceived behavioural control explains the role of users basic internet skills and the subjective norm argues the impact of peers attitude on a student to uptake using an LMS (Lee, 2010).

2.7 Media Richness Theory

The last applicable framework, Media Richness Theory (MRT) aims to explain the characteristics of technologies that decrease hesitancy and ambiguity in different business settings and can reveal another aspect of appropriate e-learning systems. Researchers showed that the media with more communication channels was more efficient for presenting materials that require less analysis. However, to present materials that need more analysis, lean media, like text, was more effective than rich media, like video. The concepts of selecting appropriate media has also been investigated in education (Liu et al., 2009).

3 E-LEARNING ADOPTION AND CONTINUED USE FACTORS

Researchers (Sun et al., 2008) have adopted these models individually or as a combination, to investigate success factors of e-learning acceptance and continued use. Five main critical success factors can be synthesised from the findings. These are identified as teacher attitude and skills, student attitude and skills, LMS design, Learning materials characteristics and external support. This section explains each factor in further detail.

3.1 Teacher Attitude and Skills

Instructor behaviour toward virtual learning environments (Sun et al., 2008) as well as the technical capabilities (Benson Soong et al., 2001) has an important role in student behaviour towards an LMS system. In a survey conducted on 900 students, Selim (2007) showed that the instructor's interactive learning attitude is one of the most critical factors that can entice students to actively interact on an e-learning system.

3.2 Student Attitude and Skills

The computer knowledge and previous experiences of students are also significant factors that influence adoption and acceptance of an e-learning system. Researchers have identified the self efficiency and experience of students using the technology as a significant factor (Chiu and Wang, 2008) while anxiety can be identified through a lack of knowledge and skill and can cause a major negative outcome (Sun et al., 2008).

3.3 LMS Design

One of the most important factors that impacts on using an LMS is how the system is designed. Different characteristics have been highlighted by researchers that can affect the intention to use an e-learning system which are:

- *Perceived ease of use* which is sometimes called effort expectancy (Chiu and Wang, 2008) or perceived behavioural control (Lee, 2010).
- *The interactivity of the system* (Pituch and Lee, 2006)
- *User friendly interface design* (Selim, 2007)
- *Complete and easy to understand information of the system*

3.4 Learning Materials Characteristics

The learning content that is delivered through an LMS system and the pedagogical approaches that are followed in a unit should also support e-learning. Effective learning content should consider the following criteria:

- *Perceived usefulness*
- *Accuracy and completeness*
- *Performance expectancy* which is referred to the level of short term perceived usefulness
- *Intrinsic value* which is referred to the degree an activity is delightful
- *Utility value* which is the relevance of a system to future career objectives or long term usefulness
- *The collaboration level of learning materials*
- *The compatibility between learning objects and student requirements*
- *Relative advantage*

3.5 External Support

Support from the institute and the peer impact are also important factors to be considered in the use and implementation of an LMS. The educational organization should provide:

- *Computer labs*
- *Reliable networks*
- *Technical troubleshooting*
- *Information accessibility*

Subjective norms or the peer impact also proved to motivate individual intention to continue using an e-learning system (Lee, 2010).

4 DISCUSSION

A synthesis of the literature and frameworks presented here allows for the identification of a three-phase timeline explaining student behaviour. Although the important components in each phase overlap the factors in the other phase, this classification gives a better understanding of the required steps that lead to the effective implementation and use of an LMS (see figure 1). The timeline and the relevant critical factors in each phase are discussed in this section with more details.

The first phase deals with the essential factors that need to be considered before the use of the LMS. Previous student computer skills and knowledge of ICT is one of the most important pre-requisites of a successful LMS experience (Chiu and Wang, 2008). The more a student is ICT competent, the less effort that is required for the student to adopt and use the e-learning system. However, more experienced users may expect more advanced features in the system.

The second phase of an LMS acceptance occurs while students start using the system. In this phase, the LMS design, the quality of learning materials, teacher attitude and external support plays a significant role in encouraging students to continue using the e-learning system. In terms of LMS design, the richness of the media used in presenting the learning martials (Liu et al., 2009), the response time, the interactivity of the system (Pituch and Lee, 2006,), a logical navigation structure, easy and good access (Sun et al., 2008) and the design of the interface all impact on the students intention to continue participating in an e-learning environment.

The Learning materials must be compatible with the virtual learning environment (Papp, 2000), have a level of joyfulness (Chiu et al., 2005), be accurate and comprehensive. Consequently, the design and use of teaching experiences that enhance the sense of equality and community among students can encourage students to be more active in virtual learning environments. While the design of the teaching experiences is quite important the assessment model used must also be supportive of this. The assessment can play a large factor in student attitude toward the use of the LMS (Sun et al., 2008)

In this phase, the behaviour of peers is also seen as an external motivation and may change how a student interacts with the LMS since social influence is proved to be effective on an individuals attitude (Lee, 2010). The availability of computer labs, the network reliability, troubleshooting support and information accessibility are other required external supports that are vital in the success of an e-learning program (Selim, 2007).

Considering the ECM model discussed earlier, the users first experiences of the system forms their ongoing approach and continued use which is the third phase of the timeline (see figure 1).

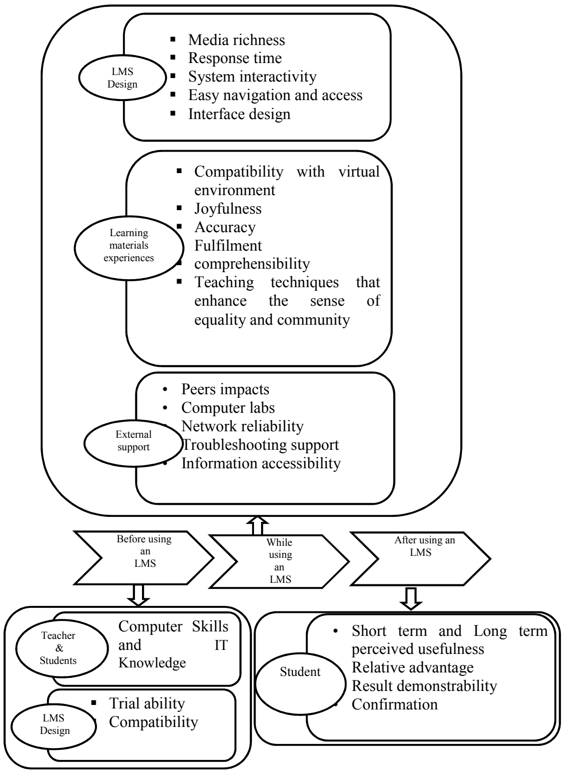

Figure 1: LMS adoption and Acceptance Timeline.

The users short term and long term perceived usefulness of the system (Lee, 2010), (Pituch and Lee, 2006), and the feeling of relative advantage in using an LMS (Liao and Lu, 2008), as well as the tangibility of the results and the level of confirmation of initial expectances create a level of user satisfaction that forms continued use behaviour.

5 CONCLUSIONS

E-learning and more recently blended learning is used significantly in higher education teaching and learning, however, it is critically important to use it in ways that support and promote positive learning experiences for students. The existence of learning tools in an LMS does not automatically result in them being used for positive or effective teaching and learning experiences. The synthesis of literature presented here highlights the critical factors that affect the success of an LMS and how to plan for success. The five factors involving teachers, students, learning materials and pedagogical approaches, LMS features and design, and external supports need to form an essential component of a successful LMS implementation. An LMS implementation needs to be planned and teaching staff need to be aware of the factors that can lead to its successful use as an essential component of teaching and learning within higher education.

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Time as a Heuristic in Serious Games for Education

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Abstract: The article proposes a conceptual framework for studying the organization of time in educational games. A time-focused analysis can productively examine time frames and time work in a serious game, in order to understand its timescapes of learning, and its politics of time. Games may be designed to accommodate strategies of play of variable time intensity, to assist players' time work, to support dynamics of learning, to encourage knowledge of history and foresight, and to illustrate various economies of time.

1 INTRODUCTION

This paper is written at the convergence of two topics of growing relevance. On the one hand, new communication technologies lead to *transformations in temporal experiences* – especially to feelings of time acceleration and scarcity (Wajcman, 2008); they also make possible new tools for measuring and monitoring time, planning and coordinating activities. On the second hand, there is an increasing understanding and *use of digital games as learning experience* (Prensky, 2001); (Gee, 2003). Digital games are sophisticated constructions that require time to play, make time go by faster, create new time lines, include instruments for tracking and allocating time, and, all in all, allow for a rich array of "time work" activities (Flaherty, 2003). We focus on the *time of gameplay in educational settings*: how can it be productively analyzed? How can it be designed to support learning?

Time is a rare topic in studies of educational games, particularly in engineering, because they often involve simple play strategies, do not require player coordination, and their play time (duration, timing, synchronization etc.) is regulated as a classroom activity (see for example J.M.D. Hill et al., 2003; Eagle and Barnes, 2008; Maragos and Grigoriadou, 2007; Leong et al., n.d.). Still, games with more complex strategies require time design and management. This applies to games that last longer, for voluntary games that invite players' attention outside classroom hours, as well as for learning based on social gaming, in which players' synchronization and the constitution of longer-term communities are crucial objectives (see Hicks, 2010; Yoon et al., 2011; Whitson and Dormann, 2011). As students and instructors gradually become more sophisticated game players, complex design, with rigorous time organization, becomes an increasingly available option, possibly even required for learning impact.

We argue that *time is a useful heuristic in designing and evaluating digital games for education*. We propose a conceptual framework to guide the inquiry. We discuss "timescapes", "time work" and "time frames" as useful analytical tools to study temporal arrangements and the politics of time in any project. We then examine the heuristic productivity of a time-focused lens in the study of educational games, and we formulate several orienting questions.

2 CONCEPTS AND QUESTIONS IN THE STUDY OF TIME ORGANIZATION

What are the merits of a "temporal gaze" (Adam, 2000), an analytical perspective focused on time? Looking at several analyses that put to work empirical evidence to theorize time, such as Adam (1990, 2000), Levine (2003), Roth et al. (2008), Too and Harvey (2009), and Mercer (2008), we can see that such a focus address two main concerns:

1) On the one hand, it supports an examination of the "timescape" (Adam, 2000; Too and Harvey,

2009) in which a phenomenon takes place. If landscapes include all elements of context that inform actions, timescapes make explicit the dimension of time. We can thus observe how some actors take into account (or ignore) possible "temporal horizons" (Hitlin and Elder, 2007) (for example: the near past, the distant future); how activities produce resources for one another through synchronization - or fail to do so, sometimes as a matter of segregation by design (Groves et al., 2011); how reflecting on the past shapes the evolution of a social practice. If we become alert to the timescape of a social activity, we can then proceed to extend it beyond taken-for-granted time borders. For example, we can pay attention to its histories, pre-histories or preparatory stages (Levine, 2003); (Adam, 2000); (Mercer, 2008), or to its post-events and various futures.

2) On the second hand, a focus on time makes us aware of the politics of time: how does a certain time organization becomes 'normal' and thus normative? Who are the winners and who are the losers of a particular time ordering? What happens when several forms of time organization conflict (Roth et al., 2008)? By looking into the temporal structure of an activity, we can also see how a process defined by specific temporal horizons and resources creates results that are later used as a-temporal facts (Levine, 2003); (Adam, 2000). By noticing the regular, 'normal' organization of time we can then 'play with time': we can re-do it in a surprising setup, in order to unravel unseen social arrangements, or just 'for fun' - as in digital games that include intricate time lines (Zagal and Mateas, 2010).

For example, educational games are vulnerable to problems introduced by divergent gaming styles. Students who dedicate long hours of play, with a power gaming orientation, become game elites – while more casual players are disadvantaged and discouraged to play. The management of time is crucial in order to balance different objectives of educational games – such as to engage players, to offer a level playing field, and to maintain convergence with course objectives. Game designers may introduce incentives to orient play strategies; still, results depend on players' contextual ways of dealing with technological affordances and limitations.

When looking at how designers and players configure gaming experiences, another useful concept is *time work*, which Flaherty (2003) defines as "efforts to control or manipulate duration, frequency, sequence, timing, and allocation" of time for a given activity. This concept is useful for directing our attention towards people's agency in *making* time, in changing the timescapes that in turn contextualize their actions.

2.1 Time in Games

Time is an important concern for game designers (Tychsen and Hitchens, 2008). Gaming experiences are shaped by many calibrations of duration, rhythm, speed, synchronization, and players' degree of control of game world time. In the field of video game research, there is a consistent thread of reflection concerning temporal organization (Zagal and Mateas, 2010); (Juul, 2004); (Tychsen and Hitchens, 2008). Of all conceptual distinctions, we have found Zagal's and Mateas' (2010) *classification of "time frames"* to be most useful for our research, because it facilitates the study of the relationships between a game and its social environment.

While Adam refers to rather broad time frames, such as natural, cosmic (seasons, days etc), embodied (cycles of reproduction or of cell renewal) and cultural (calendar time, clock time), Zagal and Mateas define time frames as any "set of events, along with the temporality induced by the relationships between events" (idem, p. 848). The analyst is in charge of deciding the *relevant* events that constitute a time frame. The authors differentiate four frames that they propose as being "commonly relevant" for video game analysis (p. 852). *Real world time* includes events from the player's body and her physical world surroundings. *Gameworld time* refers to events that occur in the game world, which may be initated by the players or not. Both real world and gameworld time can be productively analyzed in terms of cycles, durations, countdowns, and triggers (idem); relationships between the two frames shape the gaming experience. *Coordination time* includes events of player coordination, such as organizing rounds and turns. *Fictive time* is the set of references that link various game events to culturally-defined labels, derived from historical or fictional stories.

The advantage of this conceptualization is that other frames can be developed to include subsets of events that are relevant for a given analysis. Zagal and Mateas illustrate this by introducing the *interface frame* as the "set of events that take place in the game's user interface" (idem, p. 860). We can see that the interface frame groups events included in gameworld time; still, it is a heuristically powerful concept because it helps us observe what particular moments of gameplay are emphasized, and how players' actions are sensorially formulated and published, with consequences on players' decision context and feedback, reputations, and their resulting motivation to engage with the game.

From this perspective, we see that time work can include not only the control of the temporal properties (duration, frequency etc.) *within* a given time frame, but also the *management of multiple time frames* (inter-relating them, pushing them to the fore or background of decision-making), and the *creation of novel time frames* through which to experience or to observe time.

For example, designers of serious games may introduce *metagaming time frames*, by creating social events in which game and gameplay are discussed and reflected upon. Such events – focus group meetings, peer content generation, social gatherings involving players and designers, social web technologies (Trăușan-Matu et al., 2009) – would constitute a distinctive time frame, producing and organizing learning through reflexive gaming.

Another way of using time frames in order to adjust serious games to learning contexts consists in the configuration of the interface frame. In order to encourage a variety of play styles, a game may be internally diversified, through a looser focus on total game scores, and a more prominent role for diverse achievements. Players' status in the gameworld is dependent on their opportunities for self-presentation. An interface that brings to the fore the total game score, in which game progress is measured by quantitative changes in one's overall rank, stimulates competition, but may discourage participation at the margins of the ranking. An interface that captures and displays temporary successes, through achievements or other mentions, without melting them into a unified metric, may afford a more diverse player engagement, tolerant with uneven rhythms of gaming.

2.2 Time as a Heuristic in the Study of Educational Games

Challenges for the organization of time in games are to a large extent game-specific; there are, still, some issues of common relevance, concerning *player engagement*. Games that are used in learning projects pose additional, specific challenges. Some derive from managing *learning as a temporal process*; others refer to the timescape of the *subject matter*. An overview of these three layers of challenges is presented in Table 1; we discuss each of them below.

2.2.1 Game Time and Player Engagement

Firstly, a shared objective of games consists in *motivating* and enabling potential players *to make time for actual game play*: that is, motivating newcomers to enter the game at later times, and motivating a diversity of older players to keep on playing. We use Yee's classification of three motivational drives in gameplay, namely achievement, social life, and immersion (Yee, 2006), to discuss specific challenges:

- As regards *achievement*, a difficulty consists in loosening the strong coupling of game performance to time consumption (Steinkuehler, 2006). This uncoupling can be pursued by introducing multiple (qualitative) types of accomplishments, corresponding to different (quantitative) levels of time investment. It can also be realized by using various time metrics (duration, speed, coordination, prediction etc.) to define performance.
- As regards *social life*, common challenges in the organization of game time include: 1. supporting in-game socializing by synchronous, joint play; 2. supporting asynchronous interaction between players; 3. the creation of rich characters that display their in-game biographies and reputations.
- As regards *immersion*, it is also dependent on the temporality of game play. A game can facilitate engagement by: 1) a *fictive time frame* that supports the vividness of the game world and characters (Zagal and Mateas, 2010); 2) balancing the *speed* of game events and players' skills to maintain the flow of play (Chen, 2007); 3) managing "*dead time*" (including waiting, or character grind time) (Juul, 2004), (Van Meurs, 2011); players may also deal with dead time through rule-bending (Consalvo, 2009) that affects other players' motivation.

Secondly, games may also provide means to assist players in their time work, including the effort of converting real world time into play time. Games may support players by a variety of options and tools: the possibility of achieving noteworthy results in short lapses of engagement, accessibility on mobile devices, tools for monitoring time indicators during play (speed, duration, countdown etc.), tools for monitoring the gameworld while not playing, reminders, and so on.

Thirdly, game designers may consider engaging players in the evaluation of the game and the construction of future editions, thus articulating the game history with players' biographies.

Table 1: A time-focused perspective on educational games.

Topics		Game timescapes	Game politics of time
All games	1.Time in games	1. Motivating players: uncoupling achievement from time consumption; supporting socialization and in-game biographies; creating a gameworld with a distinctive experience of time; 2. Supporting players' time work; 3. Engaging players in the game evolution;	1. What sort of time work is required to become part of the game elite? Who are the 'top players'? 2. What sort of time work is required to participate in the game evolution? Who participates?
Educational games	2.Time in the process of learning	1. Influencing the quantity of time, for game and non-game learning; 2. Influencing the quality of time, for game and non-game learning; 3. Shaping the time allocation and sequence of learning activities: exploration, study, practice, repetition, out-of-the-box connections, meta-communication;	1. What values are embedded in the game and non-game activities of learning? 2. How does the game modify the relationships in the learning project (between students, and between instructors and students)? 3. How is the game elite related to the elite of non-game learning activities? What powers accrue to each status?
	3.Time in the learned-about world	1. Learning histories; 2. Learning various economies of time.	1. What note-worthy events and persons are highlighted to narrate a history? 2. What selected economies of time are introduced?

2.2.2 Time in the Process of Learning

Learning unfolds in time, and it is about topics that take place in time. If we think of learning as a process of mastering a novel symbolic (and material) world, then we can distinguish the time created by this process itself, and the time included as a dimension of the world under study. We can then ask two questions:

On the one hand, how does play time influence the time of the process of learning (in play and non-play activities)? On the second hand, how does the game influence the time of the learned-about world?

As regards the first question, there are at least four ways in which games are relevant:

1. Play time *changes the quantity of learning time*, by displacing other activities. Given that games are usually associated with leisure, an educational game can be used to push learning activities in time zones which would otherwise not be formally available, such as holidays or night hours;
2. Play time *changes the quality of learning time*, in both play and non-play activities. Gameplay has the potential to re-define non-game activities in the learning project, for example by making them seem rather boring, or, alternatively, by giving them new meaning, by association with game-created information or social networks;
3. Play time *changes the time allocation and sequence* of various learning activities, such as exploration, study, repetition, practice, out-of-the-box thinking (for example, with metaphors and analogies), meta-communication and learning about learning (Bateson, 1972);
4. Last but not least, the game *introduces a different economy of time*: time investment in the game leads to other benefits than in the non-game activities. Educational games may cultivate players' understanding of time economies, by design. Games also have distinctive criteria for performance, and creates their own elite, which is related to the game's time politics (as a rule, players that spend more time in the game tend to obtain higher scores). Since in educational games fairness is an important concern, designers often attend to time organization in order to level the playing field.

2.2.3 Time in the Learned-about World

The game may introduce *histories* of the subject-matter as a topic of learning. These histories can furnish the game's fictive time, or they can be present through various game elements: characters, quizzes or riddles, side-line stories etc. The game may also familiarize students with multiple economies of time existent in the studied domain: the times of scientific research, of company-based production, of open source development, of possibly related fields such as medicine, the military, politics etc.

2.2.4 An Illustration: World of USO

This article was written as a reflection on the serious game “World of USO” (WoUSO), developed since 2007 in the Computer Science Department of University POLITEHNICA of Bucharest to accompany a course on Using Operating Systems (USO). The game is presented in detail in Rughiniș (2012); for the purpose of this article we should note that it serves as an accompanying activity for the USO course, aiming to stimulate student sociability around CS topics, and to foster a playful orientation in technical work and learning. WoUSO is an open source project, in which students and former players are invited to participate; each academic year the game lasts throughout the first semester, until the course ends. The game is complex, including several activities; its main components are: Question of the Day (QotD), a daily quiz question from the course curriculum; Weekly Quests, sets of riddles on general technical and CS culture topics, with a whimsical outlook; daily Duels in which students challenge one another and compete by answering sets of 5 quiz questions from the course curriculum, in 5-minute asynchronous sessions; Spells used to modify actions and outcomes for oneself and for one’s opponents (increasing or decreasing rewards, hiding real scores, paralyzing actions etc.). Each game activity generates points that accumulate in the players final score; at the end of the semester, the Top 10 players are declared the winners, and the first player receives the WoUSO cup.

We have noticed that time organization in WoUSO had unexpected effects. Although each activity opens a different temporality (rhythm, schedule, duration etc.), by cumulating all points in an overall score the score-display interface frame became dominant. This frame was defined by the linear time of score growth, mainly through duels. Players who, for some reasons, did not play duels for a while fell rapidly behind in rank, and felt discouraged to re-enter the game: the linear time of score-display dominated the cyclic temporalities of the Weekly Quests, which invited players for a new adventure every week. Virtually all players but the top 20 ones, with approximation, who played competitively in order to win, were actually dissuaded in later weeks to convert realworld time into gameworld time. The game elite was finally determined through willingness to persistently invest considerable time in duels, all along the semester; time allocation was central in WoUSO politics. Moreover, since game difficulty increased along the semester, and so did the difficulty of course-related work, this led to time work conflicts between the “student” and the “player” roles, further encouraging “power players”. Since, as a rule, game winners became members of the development team for the next semester edition, the game development timescape inadvertently privileged, in design options, the “power player” style of time work.

In order to encourage a broader and more diverse student participation throughout the game, in the 2012 edition developers have changed the game interface to display more prominently distinctive scores for Weekly Quests and Duels, and have also introduced achievements to reward diverse time work strategies, such as persistence in playing, early or late hours of play. Since duels have continued to dominate the game and to structure players’ time work in this semester too, planned new developments for the next edition, in the Fall of 2013, include: the classification of players into named levels (‘leagues’) to encourage players in the lower ranks to engage one another in duels; a Grand Challenge in which all players participate through random duels; changes in scoring to raise the importance of the Weekly Quest.

We have also consolidated the metagame time frame by introducing a face-to-face mid-term encounter between players (students) and developers (former players and faculty), which has encouraged collegiality and has led to useful insights into actual gameplay and possible improvements.

3 CONCLUSIONS

In this paper we argue that time is a useful analytical lens in examining educational games, and we propose a conceptual framework to guide inquiries.

By analyzing the organization of *time frames* in a game, and its support for players’ *time work*, we can pursue two directions of investigation:

- The study of timescapes: the ensemble of time structures and practices that inform decision-making and social action;
- The study of the politics of time: how certain time arrangements become normal, how they support specific definitions of performance, and create reputations and elites.

The study of time in an educational game profits from its examination on *three layers*: 1) time and player engagement, 2) the organization of time in the process or learning, and 3) the time organization of the subject matter.

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POSTERS

Advanced Learning Environments 2016

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Keywords: Virtual Learning Environments, e-Learning Futures, Disruptive Innovation, Personalised Learning.

Abstract: In the first section we address key aspects of the future of learning environments in the context of types of change in technology environments, in particular Christensen's distinction between sustaining and disruptive changes. We consider the development of virtual learning environments up to 2016, which is essentially an evolutionary or sustaining period. We also discuss a number of possible factors which will affect the development in this period, and consider alternative perspectives which might exist within higher education institutions.

1 INTRODUCTION

The strategic future of virtual learning environments has been considered by van der Heijden (2012). Starting from the flattening growth of adoption, van der Heijden went on to carry out a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis using the language of business strategy.

There are starkly different views about the future of learning environments, some of which were accentuated in the "VLE is dead" debate at the ALT-C conference in 2009. In general, monolithic VLE’s such as Moodle and Blackboard are challenged on the one hand by even generic content management systems such as Drupal, and on the other hand by “modular” products, most particularly massive online open courses (MOOCs), as well as by elearning products which make little or no claim to be comprehensive (Pearson 2012), by innovative cloud based educational applications, and by strategists who envisage a wide constellation of learning technologies and tools, with the VLE being "merely" one type of specialist application (Millard et al, 2011).

Most of the challenges outlined above are essentially tactical, concerned with products available today and meeting today's problems and aspirations. But technology is a fast-moving area, and a key dimension of this paper is how technologies to enhance learning may develop over the next decade, and the implications of this for the virtual learning environment community today.

Academically, this paper is located in the intersection of the discipline of business strategy, together with the discipline of learning technology. Its underlying perspective is from a position of strong support for the achievements of the VLE community to date, and positive views about the but articulated, namely that the positive nature of short and medium term perspectives could well create the climate for a worrying shortfall in longer term strategic thinking.

2 LEARNING ENVIRONMENTS TO 2016

We now go on to consider some broad alternatives open to higher education institutions. These are typical of the options open to institutions currently and for the next few years in terms of the institutional strategy. We have created three existing options, and deliberately constructed a fourth option which is scarcely feasible at present. Our primary focus in this paper is VLEs by 2016.

Within the broad field of eLearning, we focus here almost wholly on virtual learning environments and their broad competitors. This largely excludes the area of content, of classroom and student personal technologies, of virtual worlds and of other important areas. This is a relatively mature market, dominated in the USA by Blackboard. According to the Campus Computing Project (2011) Moodle has a 19% share of a market that appears to be becoming increasingly competitive. The proportion of survey participants reporting that their institution uses various versions of Blackboard (including Angel and WebCT) as the campus-standard learning management system (LMS) fell to 50.6 percent in 2011, compared to 57.1 percent last year and down from 71.0 percent in fall 2006. Concurrently, Blackboard’s major LMS competitors – Desire2Learn, Moodle, and Sakai - have all gained share during this period, and new LMS providers, including Epsilen, Instructure, and Loudcloud, among others, are generating significant interest

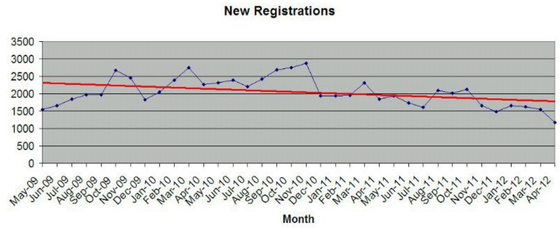


Figure 1: New Registrations (moodle.org 2012).

3 PEDAGOGIC FRAMEWORKS SHAPING VLE DECISIONS

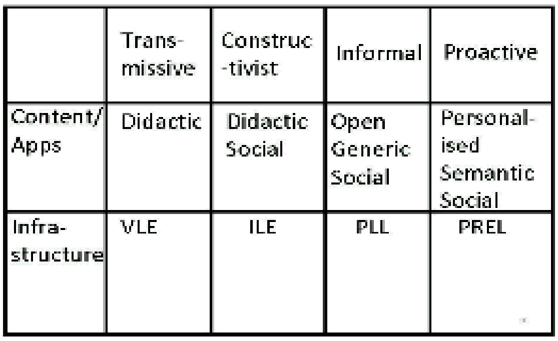
This paper reviews a variety of VLE architectures and develops one that could be expected to emerge by 2020. A pedagogic architecture needs to contain all relevant support to education, both technological and physical, and enables the relationship and balance of the components to be examined. It is vital that it clarifies genuine alternatives enables the relative costs and benefits to be evaluated. And it needs to be remembered that there will not be one right way, not even within a single institution.

We can divide the resources needed to implement a VLE into two types:

- Infrastructures - the basic level, most typically institutionally or even national; relatively static; commodity
- Content and apps - more related to the needs of schools, programmes and individual faculty and groups of students; relatively dynamic; often customised/proprietary

Today we can consider four alternative VLE infrastructures:

1. Transmissive: the traditional VLE, reflecting the traditional teaching approach in most societies. Here the VLE is used principally by lecturers as an organising tool to make resources available to students
2. Constructivist: supporting the learner to construct their own knowledge perhaps implying a more flexible, lightweight institutional learning environment (ILE) with VLE as one of several components
3. Informal: rejects formal structures and processes; auto-didactic and social; Personal Learning Landscape (PLL) with the implication that students will build their own environment
4. Proactive: Proactive Environment for Learning (PREL), involves the intensive use of learning analytics, in which data collected through the learning environment is continuously collected and analysed, particularly in real time to make mid-course corrections to modules in progress



	Trans-missive	Construc-tivist	Informal	Proactive
Content/Apps	Didactic	Didactic Social	Open Generic Social	Personal-ised Semantic Social
Infra-structure	VLE	ILE	PLL	PREL

Figure 2: Alternative VLE infrastructure.

Moodle as used by most universities is a transmissive VLE. However, Mark Stubbs (2012) at Manchester Met University sees Moodle as a way of "wrapping the institution around the learner". By contrast Hugh Davis (Millard et al, 2011) at Southampton sees Sharepoint, which is positioned by Microsoft principally as a collaboration product for commercial users, as its integrating technology and Blackboard as a narrow specialist tool.

In practice much of the support for a Personal Learning Landscape comes from those who are hostile to formal education, for instance ELGG (Tosh and Werdmuller, 2004). This is unlikely to be a feasible option for the vast bulk of universities, but VLE's and ILE's will continue to accumulate social software functionality, such as the Open University's Open Learn.

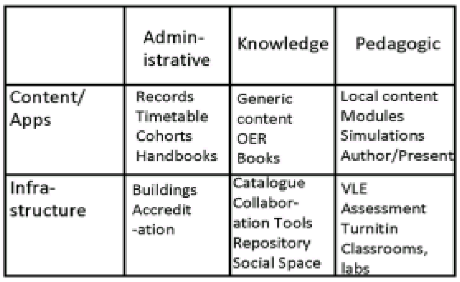
To provide a clearer and less technology-centric approach, we have built on the Southampton structure which does reference content and physical resources. It is vital to recognise three types of learning "process":

1. Administrative - important underpinning
2. Knowledge - important that this covers both explicit knowledge, such as in books and journals, as well as tacit knowledge in

humans that is shared by interpersonal communications

3. Pedagogic - what is needed for teaching and learning in any given class/cohort; can and must reflect a selected pedagogy

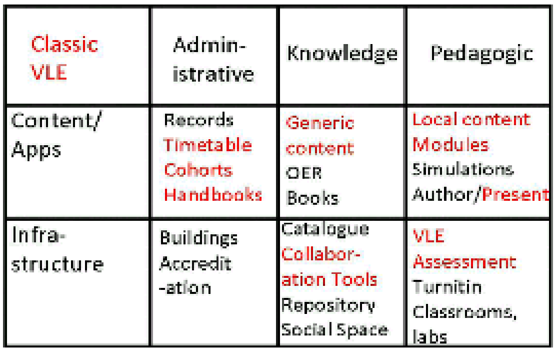
Linking these to the two types of resource produces a two dimensional framework, into which we can then allocate the various technologies.



	Administrative	Knowledge	Pedagogic
Content/ Apps	Records Timetable Cohorts Handbooks	Generic content OER Books	Local content Modules Simulations Author/Present
Infrastructure	Buildings Accreditation	Catalogue Collaboration Tools Repository Social Space	VLE Assessment Turnitin Classrooms, labs

Figure 3: Two dimensional framework.

The red in figure 4 below shows how a classic monolithic VLE includes much functionality in itself (red text). By contrast, figure 5 shows a lightweight decentralised learning environment distributes functionality (green) while possibly still retaining a VLE (red) only for narrowly defined tasks.



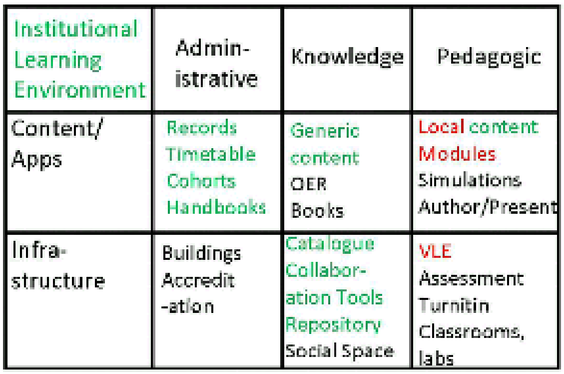
Classic VLE	Administrative	Knowledge	Pedagogic
Content/ Apps	Records Timetable Cohorts Handbooks	Generic content OER Books	Local content Modules Simulations Author/Present
Infrastructure	Buildings Accreditation	Catalogue Collaboration Tools Repository Social Space	VLE Assessment Turnitin Classrooms, labs

Figure 4: Monolithic VLE in two dimensional framework.

Consideration of a move away from formal education is nothing new. Over forty years ago Ivan Illich (1971: 72) advocated "a new style of educational relationship between man and his environment" (Illich, 1971: 72) using four channels:

- Reference services to educational objects
- Skill exchanges
- Peer-matching
- Reference services to educators-at-large

The third and fourth of these have particularly close resonances with contemporary approaches to learning environments. Peer-to-peer learning, enabled by peer matching, is a key element of any constructivist learning process. Reference services to educators-at-large facilitate the ability to locate experts - in the Tosh and Werdmuller structure provided by the social networking component.



Institutional Learning Environment	Administrative	Knowledge	Pedagogic
Content/ Apps	Records Timetable Cohorts Handbooks	Generic content OER Books	Local content Modules Simulations Author/Present
Infrastructure	Buildings Accreditation	Catalogue Collaboration Tools Repository Social Space	VLE Assessment Turnitin Classrooms, labs

VLE = red

Figure 5: Lightweight decentralised VLE in two-dimensional framework.

Hart (2001), notes that Illich prefigured the world-wide web. Laurillard (2012: 4) alludes to Illich's critique of formal education but observes that contemporary arguments against formal learning can "plunge us back into traditional approaches".

Budgetary pressures have made it driven the search for new ways to achieve (hickering and Gamson's (1987) seven principles of engagement:

- encourages contact between students and faculty,
- develops reciprocity and cooperation among students,
- encourages active learning,
- gives prompt feedback,
- emphasizes time on task,
- communicates high expectations, and
- respects diverse talents and ways of learning.

Graham Gibbs (2010) has endorsed these in his comprehensive review of how education adds value to reciprocity and cooperation among students.

MOOCs are based around a scaled version of the concept of implementing a constructivist approach to education online. In recent discussions some thinkers see them as a disruptive force within higher education. We share the scepticism expressed by Brady (2012) because of the lack of any clarity applied to the business models underlying MOOCs.

One recent initiative in the field of MOOCs is FutureLearn, supported by a range of British universities, and this has attracted significant media interest (Coughlan, 2012). Its partners include the

Open University which has proved to be a valuable addition to the higher education landscape, but it has not superseded established universities.

One particular strand of work, building on the concept of proactive computing (Tennenhouse, 2000), is proactive learning (Coronado and Zampunieris 2010), which has particularly involved developing software that is activated by actions or inactions in Moodle.

4 FUTURE DEVELOPMENTS

Technologies beyond 2016 are likely to include the educational semantic web (Anderson and Whitelock. 2004), as well as intelligent tutoring systems. Stemming from research with small children (Meltzoff, 2009), Koedinger and Aleven (2007) describe an intelligent tutoring system at university level, where cognitive tutors provide a rich problem-solving environment with tutorial guidance and response to individual student performance.

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openHPI: Evolution of a MOOC Platform from LMS to SOA

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Keywords: Massive Open Online Course, Learning Management System, Service Oriented Architecture.

Abstract: This article presents a new platform for Massive Open Online Courses (MOOC), developed at the Hasso Plattner Institute in Germany. After describing the evolution of the MOOC concept and the format, we explain how we defined the requirements for the platform, how we evaluated different open source learning management systems as candidate solutions, and how the actual platform was built. The results of two first courses delivered through the platform are presented and an outlook is given towards a planned redesign of the platform based on a Service Oriented Software (SOA) approach.

1 MOOC FORMAT AND HISTORY

The concept of Massive Open Online Courses (MOOC) has been coined in 2008 in the context of a course experiment conducted by Canadian educational researchers Stephen Downes and George Siemens, who opened a for credit course titled Conncectivism and Connective Knowledge at the University of Manitoba, Canada to open registration. The gist of the experiment consisted in encouraging learners to take the course content not as the end, but as the beginning of an autonomous and active journey defined by the connections the learner creates between resources and with co-learners (McAuley et al., 2010).

The same concept has recently been invested with a considerably different meaning when applied to University courses that are migrated from the setting of a closed physical classroom with a limited audience to an open online environment with a massive audience. MOOCs in this second sense have originated at Stanford and MIT and some of them attracted more than 100,000 participants.

Most discussions about MOOCs distinguish between these two concepts and formats, often referring to them as cMOOC and xMOOC (Siemens, 2012). At the heart of this distinction lies the tension between two opposing forces that are acting on higher education: On the one hand, higher education increasingly leaves the confines of national boundaries, and relates to supranational frameworks (e.g. the Europoean Bologna process) and global markets. On the other hand, pedagogical theories that conceive the learning process as active and social instead of passive and individual no longer are the privilege of alternative and marginal institutions or educators, but are now the backbone of commonly accepted learning designs like collaborative or problem-based learning. MOOCs, both the c and x variants, can be clearly situated in both movements:

- By offering a MOOC today, universities try to position themselves as global leaders of innovation, and as educational institutions capable of delivering high-quality education on a global scale. And in the same time invest in their attractiveness for the most talented prospective candidates.
- While a MOOC can be organized according to an established model of instruction, where teachers transmit a well-defined body of knowledge to unknowing learners that prove their progress by repeating back that same knowledge, it also offers the opportunity of integrating collaboration and exploration into the learning design. And even if xMOOCs have been criticized for a lack of pedagogical innovation, it can be hypothesized that their massive success is due both to the effervescent nature of their discussion forums and to the learning tools available in many MOOC platforms that allow creative exploration of the domain through virtual laboratories.

2 openHPI's COURSE FORMAT AND REQUIREMENTS

openHPI is a platform for xMOOCs, hosted at the Hasso Plattner Institute in Potsdam (HPI), Germany. openHPI is the result of tele-TASK, a research and development project conducted since 2004, which has brought into existence an advanced lecture recording system (Schillings and Meinel, 2002), and an online portal[1] for the distribution of lecture videos. While the tele-TASK portal has been augmented with sophisticated semantic web search capabilities (Sack et al., 2009) and social web functionalities, it mainly stayed focused on delivering lecture content to HPI's students allowing them to replay or to replace the class lecture. In the advent of the MOOC format, we see the opportunity to open up the pedagogical quality and domain expertise formerly reserved to our students to a broader audience.

While the inspiration for our project stemmed from the success of the Stanford courses about artificial intelligence[2] and databases[3] and the MIT course on Circuits & Electronics[4], we set our ambition to define a course format following a unique educational scenario: The subject domain is split up into six weekly units. For each week, video lectures, reading materials, and quizzes are produced and presented in a learning sequence. Discussion forums are set up for each week, and actively moderated by the teaching team. Learning progress is assessed through self-tests that can be taken an indefinite number of times, and homework, where points are granted and collected for the final score, required for obtaining the certificate.

For the technical implementation of the platform, it was clear that we did not want to rely on an external SAAS hosting solution, but create a platform we could freely adapt and evolve. Teaching at HPI focuses on IT-Systems Engineering, and the ambitious project of creating a platform for thousands of learners constitutes a very interesting challenge for our own teaching and research. Critical success factors for the fulfilment of this ambition were identified with respect to the delivery of content, the learning process, and community building.

2.1 Learning Content

The teaching team should be empowered to concentrate on the quality of the content by being provided intuitive and powerful tools for content editing and structuring.

The presentation of the learning content should suggest a meaningful path to novice learners while giving advanced learners the freedom to jump to topics most relevant to them.

xMOOCs draw on the distinctive engagement qualities of video lectures, chunked into small-sized segments. The platform must allow to embed video content, and to enrich it with textual explanation. openHPI uses videos from the tele-TASK portal, where lecture video recordings already exist in form of chunk podcasts and additional metadata extracted from the videos.

Learning content needs to be presented in its hypertextual structure, in order to allow learners to grasp more than a linear sequence of content, i.e. the rich connections that exist between knowledge inside and across learning domains.

2.2 Learning Process

The learning environment must support the learning process by allowing learners to test new competences and by confronting them with graphical representations of their progress. Assessment tools need to be user-friendly and interactive in a way to engage and motivate learners. The synthetic representation of learning progress must be easily accessible from any part of the platform.

Learners should be able to annotate content with personal notes only available to them and with shared notes and comments that trigger reactions from the teaching team and discussions in the learning community.

Learners should also be allowed to connect the learning experience with their own tools and devices, e.g offline consumption of lecture videos, or integration of course schedules with personal productivity environments.

2.3 Learning Community

The distinguishing feature of the MOOC format is its social event character: In the past, universities have made course materials available on institutional websites, and eventually provided feedback forms or discussion possibilities, for example MIT's openCourseWare project (Lerman et al., 2008). MOOCs take place during a given time period, and hence concentrate the otherwise dispersed participation into a coherent site of collective learning. Discussion forums should allow the teaching team to trigger participations and learners to question the content.

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[1] http://www.tele-task.de/

[2] https://www.ai-class.com/

[3] http://www.db-class.org/

[4] https://6002x.mitx.mit.edu/

Many learners are less comfortable when taking part anonymously in large groups and prefer the intimacy of small groups, eventually defined by similar characteristics like age, location, or interests. The platform should allow learners to find like-minded learners, and to define protected spaces for groups to organize a collaborative learning experience.

The platform must not lock the user into its own confines, but allow users to connect their learning experience to their social networks.

2.4 Quality Attributes

These functional requirements are mainly compatible with what many learning management systems, proprietary or open source, provide. But while weighting quality attributes (Bass et al., 2005), like stability, scalability, usability, look & feel, extensibility, maintainability, security and performance, important questions arose:

On the one hand with respect to performance: Learning management systems have been conceived for the context of schools or universities where class sizes range from tens to at the most hundreds of students. Delivering a MOOC to thousands of possibly concurrent users needs a robust technical infrastructure, and a scalable architecture.

On the other hand, we envisioned a platform that would be easily extensible in order to implement teaching methods like game-based learning, peer teaching and evaluation, and to connect to virtual laboratories.

Last but not least, we set as our goal, to attract learners through an attractive online experience that does not fall behind their experience with modern Web 2.0 platforms.

3 openHPI's TECHNICAL INFRASTRUCTURE

With the start of the openHPI project, the first task was to build up an infrastructure that scales for a potentially massive amount of users and is highly available, and to implement a suitable courseware for the desired course format.

3.1 Courseware Implementation

The first general decision to be taken was between designing and implementing an own solution based on a common web framework and the adaption and customization of an existing (open source) software project. When collecting the requirements for a courseware platform it became obvious that the development of a courseware platform from scratch would take at least 6 months of work for a full time developer team which is a huge (financial) effort for a first course with experimental character. For this reason, we decided to build openHPI on top of an existing tool, that would allow to us to gain experience with the construction, administration and delivery of massive open online courses, and that both technically and legally allowed and facilitated experimentation with and modification of the system.

While evaluating the landscape of existing platforms for the delivery of online courses it became apparent that several types of systems had each unique advantages to offer:

- Content management systems with respect to the flexibility of the management and delivery of learning content;
- Collaborative platforms with respect to the communication features;
- Learning management systems with respect to the support for quizzes and course design.

Finally the decision was made in favor of an open source learning management system, where a number of potential candidates were evaluated. Among these candidates, the projects Sakai CLE, Sakai OAE, Canvas LMS, and Lernanta (actually a LMS framework) were investigated and matched to the openHPI requirements. The evaluation results are summarized in Table 1.

Canvas was chosen because of its modern user interface and the availability of crucial functional components necessary for implementing openHPI's course design, mainly the sophisticated quiz engine for managing practice exercises, assignments and exams, the discussion forum and the user-friendly interface for creating and presenting the course module structure.

Nevertheless, it was desired that the platform did not look or behave like an actual LMS, since LMS offer users much more freedom than openHPI needs for the provision of its courses. A developer team of 4 full time working students put 5 weeks of work into the adaption and customization of the Canvas LMS, which resulted in a massive change of the Web user interface as seen by student users. The main changes were:

- complete rebrush of UI and platform navigation;
- additional content type for learning units: flexible video player;
- content navigation adopted to openHPI's 6 week course schedule;

Table 1: Comparison of Open Source Learning Management Systems.

	Canvas LMS	**Sakai CLE**	**Sakai OAE**	**Lernanta**
Course Landing Page	Customizable, Rich Text Editor	Static landing page from course information	Content Repository allows flexible content	Tasks and Activity Wall, not customizable
Content Sequence	Tool for course design (modules and content blocks)	Simple syllabus tool	Hierarchic organization of content pages	Tasks can be reordered
Learning Unit Presentation	Generic blocks inside a module	As wiki pages	See landing page	A taks is defined by only one content block
Quiz Environment	Very flexible, sophisticated UI	Complex functionality, but sluggish and overloaded UI	Only available through integration with Sakaii CLE	-
Discussion Forum	Threaded discussions, no voting	No voting	No voting	Participants can post messages to activity wall and comments to tasks
Learning Progress	Users can track visited units	Tracking of submitted tests	-	-
Announcements	Rich Text Editor	Via external RSS feed	-	-
Maturity	Closed-source version used productively by schools and universities	Used by major US universities	Experimental	In active development, used productively P2PU[5]
Scalability	Ruby on Rails, needs resources	Needs resources, but works for more than 100k users	No experience	No experience
Useability, Look & Feel	Modern UI	Feels sluggish, oldfashioned	Modern UI	Clean and stylable UI
Extendability	API, vendor plugins possible	API	Relies on extensible framework	-

- additional navigation bar for browsing the course sequence;
- integration of a helpdesk;
- enhancement of the discussion forum (context-specific discussions, tagging, search functionality).

The adoption process kept on going during the first two courses, where the development team gathered user feedback and wishes from the community to leverage the running system.

3.2 Hardware Platform

The difficulty in building the infrastructure mainly was about estimating the resources needed and depended on a) the application-dependent demand for resources and b) the number of expected participants. Due to a strict schedule for the first course on openHPI a temporary website for registration was set up rapidly and went online about 4 weeks prior to the launch of the actual courseware platform and 5 weeks before the start of the first course.

The demand for openHPI's offering turned out to be quite overwhelming: one week after the launch of the temporary registration website, the database counted more than 10.000 unique visits and about 3.000 registrations. At the point of the turnover to the actual course platform, there were more than 10.000 registered users, of which 9.000 students enrolled for the first course, 30.000 unique visits and 110.000 page impressions.

Although these numbers were a baseline for the final user count and could help when estimating the resources, openHPI was put on a flexible and scalable infrastructure using a private cloud framework (namely OpenNebula) for the operation of the adopted Canvas LMS (see Figure 1).

The private cloud infrastructure allows flexible scalability and the provision of more computing re-

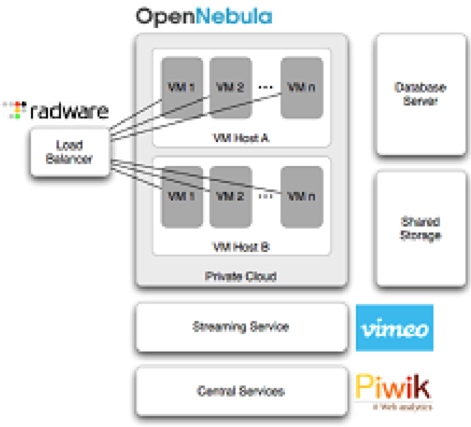

Figure 1: Overview of openHPI hardware architecture.

sources by simply adding additional physical hosts to the cloud respectively shutting down servers for reduced power consumption when the server load is low[6].

In the initial resource pool, two VM hosts were provided, each with 64 cores and 64 GB RAM as well as fast RAID 5 storage systems. Additional physical servers provide the shared database and central services like website monitoring. Incoming requests are distributed by a loadbalancer appliance that also handles the SSL sessions.

The video streaming was outsourced to the stream hosting service Vimeo, which also scales with rising demand and offers a reasonable cost model.

4 INSIGHTS FROM THE FIRST COURSES

openHPI's first two courses have met with substantial interest from the respective target audience: 13,126 learners registered for the first course, from which 4,068 actively participated and 2,137 received the graded certificate of successful completion. The second course had 9891 registered learners, with 2726 active participants, and 1635 successful completions with graded certificate. The students took about 100.000 (resp. 80.000 for the second course) self-test attempts and submitted about 18.000 (14.000) solutions of homework assignments. During the 6 weeks of course runtime, the community generated about 1.600 forum postings in the first course and more than 3.000 postings in the second course.

For the second course, we observed, that Sunday and Monday were the peak days concerning page access: up to 6.000 unique visitors generated up to 60.000 page impressions. This peak behaviour was actually expectable, since Monday was the day when the weekly homework submissions were due and the course content for the next week was published. Concerning the dimension of the available hardware platform, it never came to shortage of resources that would have led to increased response time for users even though the implemented software platform turned out to be greedy for computing resources.

The basic insight after first experiences with the implemented platform for openHPI is that traditional learning management systems are actually not suitable for the operation of massive open online courses. This insight was gained from two observations. The first one is a different demand concerning scalability: traditional universities usually offer a large number of courses with a relatively low number of participants in each course (hundreds of students). In opposite to this, openHPI offers only very few courses at a time, with thousands of students in a course. This led to massive performance problems with the Canvas LMS since many standard system operations were implemented without focus on performance but on maintainability and simply did not scale with participant numbers larger than about 1.000 students. Additionally, several UI elements (i.e. where lists of users were involved) became unusable.

The second aspect is, that LMS focus on management of courses, students, tests, learning material, etc. while the focus of a platform for massive open online courses should be on social activity respectively the activity of the students in general. Learning Management Systems are designed for courses run and tutored by teachers or teaching teams, while the openHPI courses should empower the students to peer teach each other. The restricted suitability of the LMS-based implementation of the openHPI platform manifested e.g. in the non-availability of certain features for students, that have been available for teachers. I.e. a teacher could link every content item belonging to the course within related discussion postings, while students would have to manually copy & paste the respective links or describe the item in question in their own words. In general, LMS lack the support for mixed roles between course providers and course participants.

5 openHPI's NEXT GENERATION

Based on the evaluation of above shortcomings, currently a new generation for the openHPI platform is

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[6] For a general evaluation of cloud based services in education, see (Ivanov, 2011).

planned. It will be based on a service-oriented architecture with the following design principles in mind:

- The new system should integrate with state-of-the-art backend services, if they are available as open source solutions and can be trusted to be both scalable and reliable. For example we evaluate the incorporation of digital asset management systems like Fedora.
- Service-oriented system design similar to component-based approaches strives at modularity and re-usability. Well-defined interfaces allow to separate the construction of the system into development tasks that can be executed by independent teams in parallel.
- Making services consumable from different client environments allows straightforward implementation of alternative client software, i.e. for mobile devices (mobile websites and native apps for iOS, Android and Windows 8).
- By decoupling the consumption of services in specific contexts from the provision of these services, both can evolve independently with respect to the affordances of their respective environment, for example the integration of new UI libraries, or the adoption of new communication protocols.
- A service-oriented architecture provides a sound basis for the integration of the learning platform into existing and future content production workflows. For example, we plan to integrate openHPI with the tele-TASK portal, were tools for collaborative work with e-lectures, such as live scripting and temporal (social) annotations have already been implemented.
- Allow exposure of services to third-party tools that provide value-added services to learners and teachers (e.g. personal learning environments, social networks or competence management (e-portfolio) systems.
- In the global competitive MOOC landscape, platforms need to provide unique learning tools in order to distinguish themselves from the competition. Hence it is important that the system can connect with external learning facilities, such as virtualized computing labs or simulation environments for hands-on training.

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DOMAIN APPLICATIONS AND CASE STUDIES

FULL PAPERS

Using IT Education to Reveal New Horizons

A Large Scale Case Study on Digital and Social Inclusion

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Keywords: Digital and Social Inclusion, Technical Studies, Information Technology, e-Learning.

Abstract: The development and the economical growth of a State in the sectors of Industry, Commerce (and e-Commerce), and services are directly influenced by the investments on Information and Communication Technologies (ICTs). Emergent countries like Brazil have an extremely large deficit in qualified ICTs employees. Furthermore, despite being the 6th economy in the world, Brazil currently still presents a large number of citizens below the poverty line even after a considerable improvement in recent years. In 2006, the Federal University of Rio Grande do Norte (UFRN), developed the Digital Metropolis project, whose main objective is to provide means for the creation of a ICT Development Environment in Rio Grande do Norte, Brazil. Currently, the project's main supporting activity is the Technical Course on Information Technology. In this paper, we describe the activities involving this course, its results and difficulties so far, and the future challenges we aim to face in a very near future.

1 INTRODUCTION

The development and the economical growth of a State in the sectors of Industry, Commerce (and e-Commerce), and services are directly influenced by the investments on Information and Communication Technologies (ICTs). Using the infra-structure provided by such technologies, a local environment is able to obtain the same technical results in a more efficient manner making it much more competitive in today's globalised economy. Hence, reducing the production and commercialisation costs highly depends on a larger use of ICTs. This infra-structure is composed by two important components: equipments and stakeholders. First, desktop computers, servers, computer programs and services, network and internet access are imperative resources to organisations of all sectors. Nevertheless, these resources are only useful if qualified people exist for both projecting, installing and maintaining these resources, and using them at the final end of the process.

Most of the emergent countries like Brazil have an extremely large deficit in qualified ICTs employees. Recently, an study conducted by Softex Brazil (Softex, 2010) projected a scenario in which this deficit increases considerably from 70,000 open jobs in 2010 up to something between 140,000 and 200,000 open jobs at the end of 2013. If these projections are confirmed, all economic sectors in Brazil will have their competitiveness deeply affected since, nowadays, ICTs are transversal to all productive sectors.

Despite being the 6th economy in the world, Brazil currently still presents a large number of citizens below the poverty line even after a considerable improvement in recent years. In recent research published in (IBGE, 2010), the Brazilian Institute for Geography and Statistics (IBGE), indicated that 16,27 million (8,5%) Brazilian citizens live in extreme poverty. Furthermore, current Educational Indexes like the IDEB (INEP, 2012) presented a considerable improvement (from 3.8 to 5.0 in the last seven years), but are still far from indexes considered acceptable for a developed country. More specifically, in Rio Grande do Norte, the index has been historically below the national average (from 2.7 in 2005 to 4.1 in 2012).

In this context, the Federal University of Rio Grande do Norte (UFRN) developed the Digital Metropolis project in 2006 with the support of local and national government. The project's main objective is to provide means for the creation of an ICT Development Environment in Rio Grande do Norte, Brazil. In this process, it is imperative to contribute with the formation on ICT of qualified individuals that will reduce the lack of employees previously described. The Digital Metropolis embraces this cause but adds to it a strong sense of social and digital inclusion: the project's main supporting activity to date is the Course on Information Technology whose 70% of students (ageing between 15 and 19) are from public schools.

In this paper, we describe the Course on Information Technology of the Digital Metropolis, which aims at providing professionals with high qualification in ICT whilst promoting social and digital inclusion. For that, our courses have a large scale approach in which over 2,400 students have been accepted in the last two years. In 2013 alone, this is the number of students that will be starting the course, hence, resulting in 4,800 admissions in the last 4 years.

This paper is structured as follows. In Section 2 we present an overview of the project as a means to contextualise the Course on Information Technology, which constitutes the main focus of this paper. The course's history and detailed description are presented in Sections 3 and 4, respectively. Among the course details, we describe the instrument of selection of talents (prospection), the structure of the course, its execution mode, the didactic material, the student's evaluation, and some statistics on the course's execution. The Section 5 describes the initiative of our Institute to stimulate our students to keep their intellectual development by either taking one of our BSc courses as their next academic steps, or by innovating on idealised products on a project incubation. Finally, we draw our conclusions and discuss future work in Section 6.

2 THE SUPPORTING AXIS OF THE DIGITAL METROPOLIS INSTITUTE

The Digital Metropolis was founded with the mission of promoting the interaction University-Society by complementing its functions in the axis of Education, Research and Extension on ICTs. This integration takes place in partnerships with the public, private and service sectors of society and involves various Academic Departments of the UFRN, each of which contributes with the different knowledge areas of the project. This approach favours the multi-disciplinary aspects of the Institute since, besides technological aspects, social and human factors are also considered within the project.

In the Educational axis, our mission is characterised by initiatives that promotes the formation of qualified IT professionals at various levels: from technical courses up to post-graduates. At the technical level, our objective is to stimulate vocational IT skills in teenagers aging from 15 to 18 years[1], always keeping the social and digital inclusion in context. As such, 70% of our students of the technical course are from public schools from all over the State. In the higher education, the Digital Metropolis is also innovating by creating the BSc on Information Technology and the BSc on Software Engineering. The former will start in 2013 and the later has started in 2011 and will be incorporated to our Institute as from 2013. Both courses will run in our future physical installations and aim at forming differentiated professional that are capable of taking important roles in local IT companies and endeavor in startups in the ever-growing ICT market.

In the Research axis, the Digital Metropolis aims at broading out the natural vocation of the UFRN in scientific development and technological innovation through a direct integration with private and public companies driving the practical application of research results and the technology transfer. Our objective in a near future is to establish partnerships that promote the implantation of a technological center in Natal, Rio Grande do Norte. On the other hand, this interaction will also allow the University to become aware of the real problems in society that demand high skilled research.

Finally, in the Extension axis of the project, our mission is to foster the entrepreneur vocation in the young members of the project. In that sense, the Digital Metropolis support start-ups initiatives based on innovative projects. By creating and supporting such environment, we foster the inclusion of the students of the project both from the technical courses and higher education in real life projects.

The existing synergy of UFRN and society on the three supporting axis of the project has been the key of the project's success so far. By qualifying students and integrating them with local ICT companies as well as stimulating them to open their own start-ups, we make it a real possibility to transform the State's current economical and social profile.

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[1] As described latter in this paper, in 2013, this will range from 15 to 20 years old; furthermore, we will also offer the course for students above 20 years old

3 HISTORIC OVERVIEW

The Technical Courses of the Digital Metropolis Institute started on March, 2009, with the first group of 1195 students. This first course had a duration of 15 months and its curricular structure was the basis of our current structure described in Section 4. In June, 2011, the first group of 407 students successfully finished the course. The success rate was a good indicative since our 34% success rate was well above the national average rate of 18% (Soares, 2011).

Currently, we are running the second group of students, which also started with 1200 students aging from 15 to 18 years. However, in its current three-semesters structure discussed in the next Section, the course became a Technical Course with three possible specialities: Technician in Web Programming, Technician in Computer Networks, and Technician in Electronics.

In both occasions, the execution mode of the course was online, but with weekly interventions of tutors that follow the students throughout the course. Nevertheless, as expected, our experience with the first group of students allowed us to apply changes to the daily operational execution of the course that resulted in the structure presented in the next section.

4 THE TECHNICAL COURSE OF THE DIGITAL METROPOLIS INSTITUTE

The technical courses of the Digital Metropolis Institute aim to attract young talents to the area of ICTs as a means to promote the establishment of an excellence center in this area. In this context, currently, the Institute offers three specialities in the technical courses: web programming, computer networks, and electronic. As we detail later in this section, all courses are executed with online material and weekly physical meetings. They have been prepared in a process of appropriation and production of state-of-the-art knowledge on ICTs and may contribute to the preparation of high-skilled professionals throughout Natal, helping the city to become an excellence center on ICTs.

Our technical courses target local students between 15 e 18 years old, which fit the profile of ICTs skills. In summary, during these courses the students learn basic mathematical notions, which are necessary for programming, general concepts on computational systems like operating systems and computer architectures, and programming (for the web, computer networks, or electronic circuits - depending on the specialisation). Besides the technical knowledge, students also learn to deal with technical material written in English. Finally, at the end of the course, students are motivated to undertake specialised courses and to integrate with local companies as junior programmers. At the end of these courses, our students are able to smoothly integrate into a working environment on ICTs broadening the horizons of their professional careers.

4.1 Course Structure

The courses are organized in three modules: basic module, advanced module and integration module. Each of these modules have a duration of approximately six months with a 400 hours class load. The first module (basic) aims to introduce the students to the area of ICTs and programming. Furthermore, it also offers material on technical English. During the six months of the basic module, the students take 9 subjects presented in Figure 1, which involve an Introduction to Information Technologies, Technical English, Computer Systems, and Basic Programming.

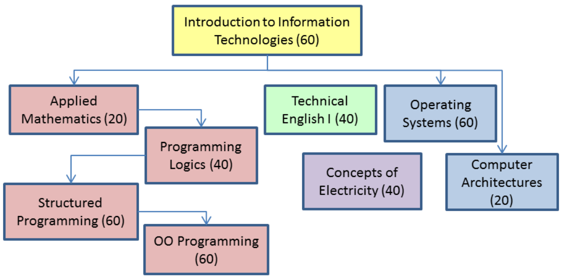

Figure 1: Basic Module Structure.

Once finished with the basic module, the student is allowed to ingress in the second phase of the course, the advanced module, in which we aim to offer a more specific knowledge to the students. Hence, when subscribing to this module, the students are asked to choose one of the three specialities of the technical course: web programming, computer networks, or electronics. Overall, during the six months of the advanced module, the students have a 400 hours class load that are divided into the subjects according to its choice as presented in Figure 2. In this module, the students of all specialities have an extended formation in technical English. Furthermore, students of web programming and computer networks study further programming and databases. After that, web programming students have a specialising training on web programming, which includes programming for mobile devices. The students of computer networks specialize in network infra-structure and security. Finally, the students of Electronics have subjects on electronic circuits, micro-controllers, radio-frequency systems, and integrated circuits prototyping.

The final module of the technical courses aims at providing an integration between academia and industry. In this module, students are able to undertake more specialised courses provided by local and national companies, which enable them to acquire more specific knowledge required by these companies. The courses also work as a link between the students and the companies that offers them, which are able to recruit the students with a more detailed analysis of the candidates skills. In our Institute, students are in constant contact with the Institute's start-up incubator. Hence, entrepreneurship is a further possibility of our egress students.

4.2 Running the Courses

All our technical courses are distance semi-attending courses. This modality allows both a concomitant execution with their standard school courses and, more importantly, a large scale offer of the courses. Currently, we offer 1200 vacancies. In 2013, this number will increase to 2400 vacancies with the plans described in Section 6.

The students are divided into groups of 40 students which happen synchronously. Each of these classes are allocated to a tutor, whose job is to follow the students throughout the whole module. Due to this nature of tutoring, the tutors are required to have a strong background on the module's subjects. In our experience, most of the tutors are students of one of our post-graduate programmes.

The tutors interact with their students both onsite and virtually. The on-site weekly meetings take place in the university. Each group of students has a 4 hours meeting per week with a fixed schedule. Overall, the meetings happen from monday to saturday in the three periods of the day. This broad availability of choices makes it possible for us to offer the course to the most number of students. The tutors use these 4 hours meetings to present a resume of the week's subjects and to answer any questions that the students have regarding the week's subjects. At the end of the meetings, students are asked to complete exercises on the week's subjects. Most of these exercises have a practical nature as they require the students to practice the theory they have learnt online. For instance, in the programming related disciplines, the students are mostly asked to provide programs that solve certain problems. The answers of these exercises are used to compose the student's final mark as described in Section 4.3. Furthermore, during the meetings the students engage on discussions about non-technical subjects on ICTs. These discussions foster their interest in the area by providing a broader non-technical view on the area.

During a module execution, the disciplines are executed sequentially. Every week, the students are in touch with 2 or 3 subjects. For each of these subjects, the students are given 1 to 3 lectures, each of which correspond to a 4 hours class load. Hence, weekly, the students are asked to study between 4 to 6 lectures (16 hours to 24 hours class load). Each of these lectures are available to the students in our Moodle based online learning environment. They have been elaborated by Lecturers of our Institution, all of which are postgraduated (PhD) in the subject of the material they have been assigned for, as we describe in Section 4.5. Besides the online lectures the students are also given the opportunity to interact with their tutors in the virtual classes that also happen in the online learning environment.

As a means to facilitate the access to both material and online exercises, the Institute offers access points to all students throughout the week. Furthermore, every student is given a media that contains all the material of the current module in execution. Hence, the student is given various opportunities to access the courses helping them to keep in touch with their classes execution.

4.3 Keep Tracking of the Student's Evolution

During the course, the students are continuously evaluated. This is enforced by the final composition of the module's grade that we explain in the sequel. For each subject, the student is graded based on three components: participation (25%), on-line exercises (25%), and the final exam (50%). The subject's final grade is the weighted average of these three components.

The participation includes both virtual and on-site activities of the student. For the virtual participation grade, we developed a tool that automatically analyses the log of the virtual learning environment and produces a weekly-based grade for each student. Among the activities that are considered in this analysis we have number of logins, time dedicated online, participation in forums, and exercises. For each one of these components, students that are above the component's threshold are given the maximum grade. Students that are below the threshold receive the grade proportionally. For instance, the time dedicated online threshold is 16 hours per week. Students above this time receive a mark 10 (ranging from 0 to 10); a student that dedicated 8 hours would receive a mark

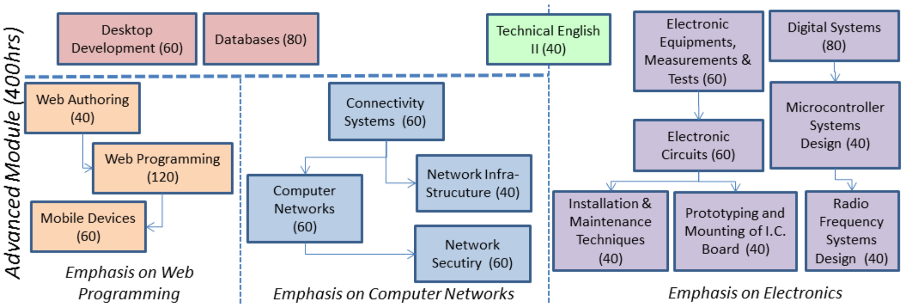

Figure 2: Advanced Module Structure.

5 on the corresponding week. The final grade of the online participation is automatically calculated by the tool; it is the weighted average of the components of interest in the log. The on-site participation is graded by the tutor and takes into consideration the participation of the students during the weekly meeting and the students results in the list of exercises given at the end of each on-site meeting.

The second component of the final grade of each subject corresponds to the student's on-line exercises. For each 4 hours lectures that is made available in the virtual learning environment, the student is asked to answer 5 exercises. Hence, overall, besides the exercises of the weekly on-site meetings, the students have a load of exercises that range from 20 to 30 exercises. Most of the exercises have a practical nature as they require the solution of practical problems. The style of these questions range from multiple choice to open questions. In case of multiple choice questions, the correction of the exercises is done automatically by the virtual environment. The remainder of the exercises is graded by the student's tutors.

The last part of the subject's grade is the subject final exam. This exam is applied twice per module, each of which corresponds to a different group of subjects of the module. Each 4 hours of class load of the subject corresponds to one question of the final exam. For example, a 40 hours class load subject contains 10 questions in the final exam. The nature of these questions is the same as that of the exercises presented to the students during the weekly meetings and in the online exercises.

Based on the three components discussed above, the student receives a final grade in each subject. The students final performance in the module, however, is given as the weighted average of the grades of all subjects of the module, where the weight of each discipline corresponds to its class load. The students with a final module average above 5.0 are approved in the module and qualify to the next module. The students that fail to achieve this mark are given a second opportunity: they are allowed to take a second final exam. After this second exam, the final grade of the module is recalculate. The same requirements for approval apply to this very final mark. Students that fail again to achieve the threshold of 5.0 after the very final exam are excluded from the program, but may take part in the entrance examination again. As the integration module is composed only by activities, this is valid only for the basic module and the advanced module.

When the basic module is finished, the approved students are given the choice of the emphasis of the advanced module. Since some of the emphasis have a limited number of places due to physical limitations, we give the priority of choice to those students with better final grade in the basic module. Every student, however, is allocated to some class in the advanced module. In cases in which the student's choice for the advanced module is not available, he is allocated to another emphasis. The grading of the advanced module is very similar to that of the basic module.

During the modules execution, a thorough follow-through of the students participation in the course is made. This is achieved by a continuous analysis of the student's participation and exercises, which allows us to identify students that have a performance below average. In such cases, we invite this students to personal meetings with the team of social assistance of the Institute. Based on these meetings, we identify the student's needs and accommodate our resources in order to solve the issues. In some few cases, this also involved the Psychology team of the Institute.

4.4 Prospection of Talents

The evaluation tool used in the selection of candidates willing to access the technical courses of our Institute was composed by 30 multiple choice questions, each question having only one correct option among five possible choices. This evaluation tool was supposed to cover a set of abilities and competencies considered critical for an IT formation and career, and was based on a certain number of assumptions related to this operational target of selection. These abilities and competencies are seen as structural modalities of intelligence, necessary in pragmatic, situated knowing, having variable degrees of complexity. In other words, the instrument was not focused in formal-conceptual, informational school-like aspects of knowledge, covering instead strategies of data analysis in the context of problem-solving procedures and differing from traditional school evaluation instruments (Primi, 2003). So, the assessment contemplated the expertise described in the National Curricular Parameters (NCP) (Educacional, 2012) in some of specific knowledge areas, particularly in the domain of languages, coding and their technologies (2000), which is more promptly associated with the identification of talents and skill building in ICTs.

For example, the assessment was composed by questions of exploration of the familiarity of the students with the following skills:

- ”Understand and use the symbolic systems of different languages as a means for cognitive organisation of the reality by the constitution of meanings, expression, communication ann information¨ (NCP, 2000, p. 6)”
- ”Analyse, interpret, and apply the expressive resources of the languages, relating texts to their contexts, by the aid of their nature, function, organisation of manifestation, in accordance with the conditions of production and reception (NCP, 2000, p. 8)”

We understand this paradigm of assessment appraises the high levels scholar skills, which are fundamental to a better performance in the technical courses of our Institute. Additionally, this might provide an incentive for schools on our state to adopt the NCP, enhancing the aggregated value of our proposal. On the other hand, despite the need and importance of defining a paradigm for the assessment, the orientation around the NCP was not enough for building the intended selection mechanism, mainly because the NCP do not deal directly with professional formation, and even less when dealing with ICTs. The assessment also needed to ensure that the selected students had an indicator of talent in specific areas such as computer programming, for example. The assessment incorporated an investigation of the students skills and vocations related to ICTs, even in an emerging state, as a means for amplifying their success in the courses of the institute and, consequently, attending our targets of providing the students with a high degree of ICTs formation and capability of getting a job after the courses.

The process of assembling the evaluation instrument mentioned above was based firstly on the proposition of a limited set of competencies and abilities demanded by environments and situations related to IT (stage 1); once these competencies and abilities were established, stage 2 was characterised by the decomposition of these competencies and abilities in smaller units allowing the proposition of descriptors over which specific items could be proposed (stage 3); the set of items constituting the complete evaluation tool was then applied to the group of candidates (stage 4), allowing finally to the constitution of the selected group of students entering in our courses (stage 5).

In this direction, we have elaborated an evaluation instrument oriented by: (1) on the paradigm side, the investigation of the skills every student should develop in the areas of languages, coding and their technologies, and; (2) on the pragmatic side, the investigation of talents directly associated with the skills and vocations of ICTs. Below, we list the set of talents, vocations and skills that deal with this pragmatic aspect of the assessment, which were inspired by the indicators of the International Society for Technology in Education (ISTE)[2].

1. Creativity and Innovation
   (a) Apply knowledge in the construction of new ideas, products and processes.
   (b) Use models and simulations to explore systems and complex situations.
   (c) Identify trends and foresee possibilities.
2. Communication and Collaboration
   (a) Communicate ideas through diversified ways of registering.
   (b) Develop an appreciation and understanding of different cultures.
   (c) Contribute to the assemblage of situations and times capable of solving problems and producing original works.
3. Research and Information Management
   (a) Localise, organise, analyse, evaluate, synthesise, and ethically use information from diversified sources and medias.
   (b) Evaluate and select information sources and digital artifacts appropriated for specific tasks.
4. Critical Thought, Problem Solving and Decision Making.
   (a) Identify and define authentic problems and significant questions for investigation.
   (b) Collect and analyse data aiming at making decisions in specific situations.

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[2] https://www.iste.org/

   (c) Use multiples processes and diversified perspectives as a means for exploring alternative solutions for non-canonical problems.

5. Concepts and Procedures in Technology
   (a) Comprehend the use of information systems.
   (b) Effectively and productively select applications and platforms.
   (c) Apply knowledge in the creative use of new technologies.

This structure aimed at maximising chances of selecting students who would stay longer and be more successful in our courses, since they would already have at least a few of the skills and a sense of the digital culture we wanted to develop. Furthermore, the assessment questions blended content and contexts of digital media, drawing very explicitly on students' common-sensical knowledge of IT.

4.5 Digital Material

The didactic material of our courses have been elaborated by a team of over 30 PhD lectures of the UFRN, each of which was supported by an assistant (normally post-graduate students). Furthermore, the unprocessed material went through a thorough revision process that included: grammatical revision, analysis of the language use in accordance to distance learning standards, accordance with rules of the Brazilian Association of Technical Rules (ABNT)[3], and a diagrammatic edition that made the final material more accessible and attractive for the students. Overall, the whole process of creation, revision, and edition of the didactic material involved a group of over 60 people.

In total, our portfolio includes 320 lectures and 3200 exercises on all disciplines discussed in Section 4, each of which corresponds to 4 hours class load of one discipline. This material is available to all students in the virtual learning environment. In Figure 3, we present a sample of the material as presented to the students.

4.6 Current Results

In 2010, the entrance examination had a number of 7000 candidates for an offer of 1200 vacancies in the course (rate of 5.83). This number considered increased in 2011, when we had a number of 13500 for an offer of 1200 vacancies (rate of 11.25). This year, as we will describe in Section 6, we considerably increased the number of vacancies and geographically distributed the course throughout the State. In 2012, the number of candidates stabilised in 13300 candidates, but now we offer 2400 vacancies in the course, bringing down the acceptance rate to around 5 (5.54).

So far, only students from 2010 have completed the basic and advanced modules with an acceptance rate of 34% (407 students), well above the national average of 18%. Interestingly, the rate of students according to the sector of their schools (either public or private), which was 70-30 at the beginning of the course (see Section 1), proved to stay almost constant in the group of graduated students. In the end of the course, this rate was of 67-33. This was a strong indication of the success of the instrument used in the prospection of talents.

Initially, the course was planned to be a basic formation course. Nevertheless, during the execution of the first version of the course, we identified its potential to become a course that offered a technical degree to its graduated students. The students of 2010 that completed both modules have been given the opportunity to re-ingress the course along with the students of 2012. A total of 269 students (67% of the graduated students) started the new version of the course which offers the technical degree. From those, 140 (52%) are finishing the missing disciplines which entitles them to start the integration module. From the group of 1200 students that started the course in 2012, 517 (43%) students have concluded the basic module and are currently in the advanced module.

The number of students that are currently trainees in local companies is considerably high (over 50), specially considering that they have not yet started the advanced module. Their performance in these activities will be the object of study in the next months.

5 A STEP TOWARDS GRADUATION (AND POST-GRADUATION)

Besides providing our students with a technical course that provides them with skills on ICTs, the course presented here aims at attracting these students to the area and open their horizons. Among the options for their near future, throughout the course, we stimulate both (non-excluding) innovation-based entrepreneurship and graduation. For that, our institute provides both a start-up incubator and undergraduation courses. Among these courses we highlight the recently created 3 years long bachelor's degree on Information Technology (BIT), which entitles the graduated students to automatically choose to follow-up on a second graduation on either Computer

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[3] http://www.abnt.org.br/

Para executar um Servlet no Eclipse, utilize a opção **Run as / Run on Server** que aparece no Eclipse ao se clicar com o botão direito em cima do Servlet (veja a Figura 4).

Figura 4 – Executando um Servlet no Eclipse

Figure 3: Sample of the Online Didactic Material.

Science or Software Engineering courses. From 2014, the BIT will receive the best students of our technical courses, broadening the possibilities of our students.

Yet another initiative that we will start from 2013 is the ICTs Olympics Competition for students aging below 15 years. This competition will cover the whole of our State and enable students to have a first contact with ICTs. From 2014, our technical courses will provide free seats for the best students of this competition.

Hence, by implementing these two initiatives which are currently under development, we will considerably broaden the public of our Institute and, more importantly, provide all students of our state with new horizons, starting from the middle school, towards graduation.

6 CONCLUSIONS AND FUTURE OF THE COURSE

Despite the good results reached so far, the road ahead of us has still a considerable number of challenges. We have already started dealing with some of them. For example, in 2013, we will start to spread the course (originally executed only with the capital of our State, Natal) to the whole of the State. Next year, three new cities will be offering the course in the same *modus operandi* as the one offered in Natal. They are Angicos (170 Km), Mossoró (272 Km), and Caicó (277 Km), which cover the main economical regions of our State.

The course's expansion has not only be geographical, but also in numbers and age groups. First, from 2013, the Institute will offer 2400 vacancies spread in the 4 cities in which the courses will be executed. Although doubling the current number of vacancies, we aim to keep this expansion in order to achieve our target of 5000 students by 2015. Yet another expansion is regarding the age group: from 2013 we expanded the age of the core group of students which will range from 15 to 20 years. Furthermore, students aging above 20 years will also be offered 20% of the vacancies.

A third dimension if the course's expansion in 2013 is the list of possible emphasis in the advanced module. In 2013, the course will also offer the emphasis on Industrial Automation in the advanced module. Furthermore, we are currently working on the creation of the emphasis on Digital Games that will be included in the list of emphasis in 2014.

Another important challenge is regarding the course's digital material. Currently, due to the already difficult challenges and innovation of making the course as it is happen, the vast majority of the digital material is not interactive. We are currently running a thorough revision on the whole material in order to include more interactivity to it. This revision will expand the current material with screencasts, animations, and interactive exercises. Furthermore, a further revision to the whole course is planned by 2015. In this second revision we aim to provide the possibility of a *progress-as-you-learn* courses like those provided by Coursera [4].

We are also facing the challenge of consolidating the integration module. Although we have already established important partnership with local companies and with international companies like IBM, we still need to consolidate this module and systematise the follow-up of the students. Currently, we are expanding our contacts with local and national companies in order either broaden the number of courses offered in the integration module or to attract these companies to the Institute. Furthermore, we are implementing a system that will systematise the student's follow-up in order to provide important information that will help the management of the large number of students in this module.

We are strongly confident of the success of our initiative. Mainly, the results reached so far have strengthen this confidence. In a near future, we expect these results will directly affect our State's economy and completely change the current horizons of our students by using ICTs and a means for that.

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[4] https://www.coursera.org/

Contemporary e-Learning as Panacea for Large-scale Software Training

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Abstract: Large organizations renew their core business software with some regularity, resulting in serious challenges for in-company training officers. Especially when large numbers of employees need to be trained to use updated software on short notice, traditional face-to-face training methods fall short. Contemporary e-learning is regarded a solution for such short-term and large-scale training. This paper discusses the effect of a didactically sound e-learning solution on learning to use a new version of an Electronic Medical Record (EMR) software package. This solution not only features generally recognized e-learning characteristics like any time, place, path, and pace, but also marks the element 'just enough' to emphasize that the e-learning content only covers knowledge (concepts and procedures) necessary to perform the daily professional tasks. Around 2000 healthcare workers of a mental healthcare institution were educated online to use a renewed version of an EMR software package within two months. Results (i.e., time on task, test results, and perceived effectiveness) indicate that contemporary online solutions can help large organizations to face short-term and large-scale training problems.

1 INTRODUCTION

Organizations largely depend on business software, especially when this type of software supports core processes of an organization (Pinn-Carlisle, 1999). It is not uncommon that software companies renovate business software packages with some regularity. These new versions of core business software are a serious challenge for in-company training officers. Especially when large numbers of employees need to be trained to use updated software versions on short notice, traditional face-to-face training methods fall short. For instance, when 2100 employees need to be trained to use renewed software and a classroom-based setting is the customary option to train software skills, an institute would probably have to organize a minimum of 140 training sessions to train the total workforce (i.e., when a training session includes a four-hour training for 15 employees, directed by one trainer). If an institution has the disposal over one fully equipped training classroom (i.e., a room with at least 15 computers), this means it would take at least 70 days to instruct all employees of the institute, weather permitting it is possible to schedule two training session each day. In addition, such a training set-up entails large organizational costs, since 2100 employees should get half a paid day off and receive travelling expenses to attend a training session. In situations like this e-learning is often considered a panacea for learning and instruction (Clark and Mayer, 2011; DeRouin et al., 2005; Driscoll, 2012; Jochems et al., 2004). Since learners can proceed through an e-learning course at their own place and pace, and at any time, organizational costs related to aforementioned organizational issues can be minimized. Moreover, contemporary e-learning offers opportunities for flexible instruction that is tailored to the requirements of learners (Clark and Mayer, 2011; Shute and Towle, 2003; Stoyanov and Kirschner, 2004). However, until recently for many organizations e-learning has proved long in lead time to produce, inflexible to amend and prohibitively expensive. Furthermore, the development and implementation of e-learning has been exclusively reserved to information technology experts, rather than educational specialists. Fortunately, due to a technology shift, new and relatively easy to use tools have become available for educationalists and trainers to facilitate e-learning development and implementation (Driscoll, 2012; Weller et al., 2005).

This paper describes a project that used user-friendly tools to create didactically sound e-learning courses for a variety of Electronic Medical Record (EMR) software users of Mondriaan, a large Dutch institution for mental healthcare. Around 2000 employees of Mondriaan had to be trained within two months' time to use an upgraded EMR software package called Psygis Quarant. Since employees needed to be trained on short notice and training facilities (i.e., availability of classrooms and trainers) were relatively scarce, it was decided to look for an e-learning solution. In addition, the intention to develop e-learning courses geared the adoption of contemporary instructional design guidelines for designing the courses. An example of a state-of-the art principle for designing instruction is the whole task approach as basis for creating learning tasks (Merrill, 2002; Van Merriënboer and Kirschner, 2013). According to Merrill (2002) "learning is promoted when learners are engaged in a task-centered instructional strategy. […]. A task-centered instructional strategy is a form of direct instruction but in the context of authentic, real-world problems or tasks. […] The effect of this strategy is enhanced when learners undertake a progression of whole tasks." The task-centered instructional strategy and other effective design principles, like the demonstration principle, the application principle, and the activation principle were employed to design the e-learning courses.

An important goal of the Mondriaan project was to study the effect of the instruction (i.e., the e-learning courses) on EMR skill learning. Therefore we explored student behaviour within the e-learning courses and analysed perceived effects of these courses on EMR skill learning. Results of the study were used to compare the e-learning approach to skill learning with customary classroom and onsite training methods.

The main research question of this exploratory study is:

- Is a contemporary e-learning method for software training effective and more efficient than a customary classroom training method?

In order to answer this question we formulated sub-questions (measurement between brackets):

- Do participants of the course perceive the course as effective / useful? (perceived effectiveness of so called superusers);
- What do participants of the course do in order to complete the course? (registration of time on task and testing results of all participants);
- Did the e-learning work? (identification of problems superusers faced within a four-week period after the introduction of Psygis Quarant).

2 METHOD

2.1 Participants

A total of 1973 employees of Mondriaan, a Dutch mental healthcare institution based in the south of the Netherlands, entered the e-learning courses. Participants belonged to one of four groups: (a) administrative staff (n=172; ADMIN), (b) nursing staff (n=956; NURSE), (c) psychotherapy/psychiatric staff (n=659; PSYCH), and (d) occupational therapeutic staff (n=186; THERA). For analysing perceived course effectiveness, evaluations of so-called superusers (n=100) were analysed. Superusers are representatives of the aforementioned groups. They function as contacts within departments and help solve problems users of the EMR software have. Further, they serve as intermediate between the EMR software user and information technologists of the Mondriaan institute. The superuser group included 26 administrators, (ADMIN), 33 nurses (NURSE), 32 psychotherapists/psychiatrists (PSYCH), and 8 occupational therapists (THERA).

2.2 Materials

2.2.1 Courses

For each of the four groups of users an e-learning course was designed. Each course consisted of two modules and a test. The first module covered an introduction to the EMR software and was the same for all users. The second module aimed at professional task learning and was different for the four groups. Each of these modules included between six and nine tasks. Instructional design principles for complex learning were used to design the learning tasks (cf. Van Merriënboer and Kirschner, 2013). Authentic tasks formed the basis for designing the learning tasks. Tasks were scheduled from easy (more instructional support) to difficult (less support). Table 1 shows an overview of the tasks covered in the courses for the four different groups.

For each task two or more exercises were designed with increasing difficulty level. During the first exercise learners were guided through the task.

Table 1: Overview learning tasks per user group.

Course ADMIN	Course THERA	Course PSYCH	Course NURSE
Registration and creating dossier	Appointments and dossier (4)	Appointments and dossier (4)	Report (6)
Unplanned activity (1)	Adapt appointment (5)	Adapt appointment (5)	Outside authorization (2)
Outside authorization (2)	Unplanned activity (1)	Report (6)	Consult archive (3)
Consult archive (3)	Outside authorization (2)	Consult archive (3)	Guidance plan
Add documents	Consult archive (3)	Anamnesis	Dialogue model plan
Make an appointment	Report (6)	Unplanned activity (1)	Gordon model plan
Outgoing correspondence	Create sub plan	Outside authorization (2)	
Register client	Day care plan	Medication	
Activity plan			

Note: Numbers indicate the same task is used for different groups. Tasks without number are unique.

In subsequent excercises guidance was faded and learner control had been increased. In the latter case feedback was only given after wrong user actions.

Each exercise starts with a realistic task description. An example of such a task description is: "*You just received the referral letter for Ms Post born 06-10-1951. You are going to register her and make an application for care for her. After that you will create her dossier. Ms Post has not been in care before.*" A task decription is followed by a 'guided interaction' with the EMR application. To develop the interactive exercises detailed scripts were written. In total about 100 of these exercises were developed for the four courses. Figure 1 shows a screenprint of an interactive exercise including feedback.

Ilias V4.2.3 (www.ilias.de) was used as learning management system. Ilias is an open source learning system that also includes authoring facilities for developing e-learning modules complying to the SCORM standards and tests using a wide variety of question types. Adobe Captivate 5.5 TM was used for building the exercises. Ilias was linked to a course/training management system called Edumanager (www.lnm.nl). Based on the function profile of the Mondriaan employee Edumanager could 'decide' which of the four courses should be offered. Ilias reported back to Edumanager when somebody passed the test of the course.

2.2.2 Tests

For each course a test was constructed containing an average of twelve multiple choice questions. Both test items and test were made in Ilias V4.2.3. Test items mainly focused on assessing (new) procedural steps. Further, questions related to the updated graphical user interface and questions aimed at assessing conceptual understanding were added to the test. Alternative answers of test items included 'anticipated errors', that is: possible errors identified by Psygis Quarant experts.

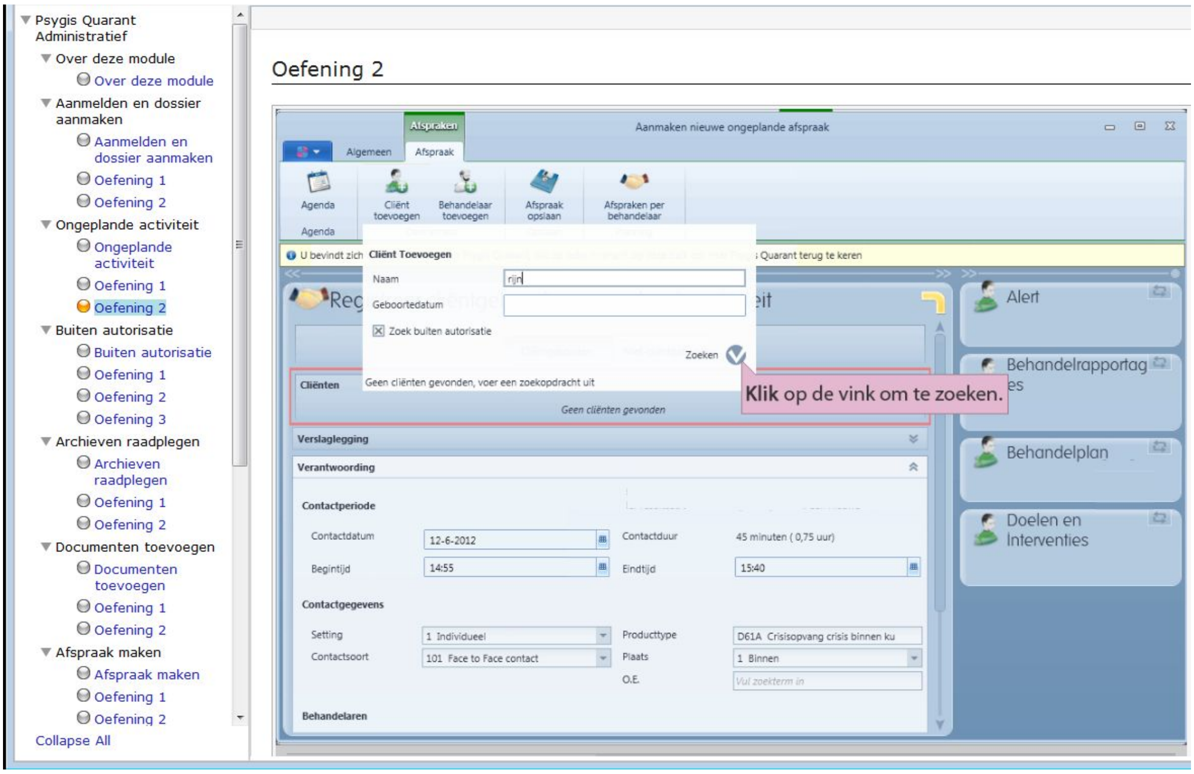
The cut-of score for the test was set at 70%. Because students were allowed to make the test multiple times, alternative answers to questions were randomized whenever possible. Ideally a question pool would have been constructed but time and resource constraints prohibited this. It was possible to quit a test and continue it later on which was practical because it could very well happen that a test had to be interrupted for more urgent work.

2.2.3 Evaluation Form

The evaluation form consisted of 10 statements that used a Likert-scale (1=completely disagree – 5=completely agree). Questions covered topics like course login, the course modules (content, sequence, readability), the test, and perceived effectiveness of the e-learning course. Questions were selected from the course evaluation database of the Open University of the Netherlands (Westera et al., 2007). Participants were able to add comments to each question.

2.2.4 Follow-up Questionnaire

Four weeks after the launch of the new EMR software a follow-up questionnaire was sent to the superusers. The questionnaire consisted of 14 questions, both multiple-choice and open questions. The questions covered problems encountered with the e-learning courses (how many, nature of problems), problems users encountered with the EMR (how many, nature of problems), and the evaluation of the e-learning tool. Questions were selected from Westera et al. (2007).



U bevindt zich ... Quarant terug te keren

Naam: rijn

☒ Zoek buiten autorisatie

Geen cliënten gevonden, voer een zoekopdracht uit

Geen cliënten gevonden

Klik op de vink om te zoeken.

Contactdatum: 12-6-2012

Begintijd: 14:55

Contactduur: 45 minuten (0,75 uur)

Eindtijd: 15:40

Setting: 1 Individueel

Contactsoort: 101 Face to Face contact

Producttype: D61A Crisisopvang crisis binnen ku

Plaats: 1 Binnen

O.E.: Vul zoekterm in

Figure 1: Sample screenshot from the e-learning course showing an interactive exercise including feedback.

2.3 Procedure

A project team was formed consisting of e-learning specialists from the Open University of the Netherlands and ICT-support and training specialists from the Mondriaan institute. A tight project plan was needed because there was only a six-month period between the start of the project and the start of the training of the employees. The project included phases for analysis, design, development, testing the course with 100 users, and implementation. The project was further complicated by the fact that it was the first time the electronic learning environment was used in the organisation. Moreover the project was used to train the Mondriaan project members to design and maintain e-learning courses themselves.

The first step for the project members was to get acquainted with the learning management system (Ilias) and to select the necessary authoring tools. It was decided to use the Ilias Scorm editor to build the modules for the course and use Adobe Captivate 5.5 TM for building the exercises. To construct the tests the Ilias test editor was used which supports a wide variety of question types.

During the design phase of the project examples were presented to a focus group for feedback. After the development phase the 100 superusers tested both the e-learning courses and the tests. Testing was done during ten workshops in August 2012. The superusers evaluated course and test content, time on task, and time on test, and filled in an evaluation form and a follow up questionnaire after four weeks. The superusers also provided the project team with valuable feedback and several errors could still be corrected before the e-learning courses and tests were finally implemented.

On 15 August 2012 all employees of Mondriaan received an email asking them to follow the course and complete the test before October 1st 2012. In the two months before the launch employees were already informed during plenary sessions and the company website. The progress during this six week period was closely monitored, reminders were mailed and in some cases department heads were informed that employees were lacking behind.

3 RESULTS

In order to answer the main research question of this exploratory study, three sub-questions were posed. In this section we will present the results necessary to answer the sub-questions.

3.1 Perceived Effectiveness

In order to measure perceived effectiveness, 100 superusers were asked to fill in a questionnaire after the testing session (a two-hour workshop). Seventy-two out of 100 returned the evaluation form. This group was very positive about the e-learning. Sixty-seven of 72 (93%) superusers indicated this form of learning was well or very well suited for learning to use an EMR. Also the specific course offered got good marks:

- The structure of the course is logical: 98% agreed or strongly agreed.
- Text was clear: 95% agreed or strongly agreed.
- Interactive exercises easy to understand: also scored 95%.

Answers to the questions about the tests were also positive, be it less outspoken:

- The questions were well formulated: 89% agreed or strongly agreed.
- The questions were well connected to the course content: 63% agreed or strongly agreed.
- Mastering the EMR software is tested well in this way: 72% agreed or strongly agreed.

3.2 Course Progress

What did participants of the course do in order to complete the course? Between 15 August and 1 October 2012, 1973 employees of Mondriaan followed the e-learning course and completed the test. During this six-week period, the e-learning ran without any significant problems. A few people complained they were offered the wrong course; this was corrected manually. After six weeks almost 80% of all Mondriaan employees had successfully completed the course. Table 2 presents the number of employees that followed and completed the e-learning courses and tests (successfully).

Table 2: Course completion rate.

	No. users	No. completed	% completed
ADMIN	172	132	77
PSYCH	659	483	73
THERA	186	151	81
NURSE	956	749	78
Total	1973	1515	77

Note: reference date 3 October 2012.

Table 3 presents the time participants spent on the course and the test. Overall it took the students about one and a half hour to complete the course of which about 20 minutes was spent on the test.

Table 3: Time on course, time on test and score test for each function group.

	Time course	Time test	Score test
ADMIN	1h46m	17m	88%
PSYCH	1h29m	15m	85%
THERA	1h41m	17m	84%
NURSE	1h22m	23m	80%

Note: reference date 3 October 2012

The average of one and a half hour for time on course was well within the two hours that was estimated for a classroom course on the topic.

The variation in study times suggests that the freedom learners have compared to classroom instruction is welcomed by many learners. Table 4 for instance shows a large variation in study times of the administrators (ADMIN) course learners.

Table 4: Study times in minutes related to number of learners that completed the ADMIN course.

Time (minutes)	0-30	30-60	60-90	90-120	120-150	150-180	>
Learners	15	12	28	33	11	11	26

3.3 Course Quality

Did the e-learning work? Four weeks after the launch of the new EMR application an online questionnaire was sent to the 100 superusers. After one week 59 out of 100 had filled in the questionnaire. The first two questions asked for problems with the e-learning. The amount of problems with the e-learning they received was limited. 75% of them received 5 or less problems during this period. Only a small amount of problems were actually related to the content of the course. Most problematic (19 times) was making the new password needed to access the course. Second were complaints about having the wrong course offered (usually outdated or wrong information in the personnel system). Several other problems were mentioned some of which very useful in the context of further development. But on a total of almost 2000 users the amount of problems was minimal certainly taking into account this was the first time e-learning was used. The question whether e-learning was a good tool to use for this kind of training was agreed with by 78% of the respondents.

Other questions looked into the problems users had with using the new EMR application. In this case more problems arose: 60% of the superusers received 5 or less problems during this period. But also in this case most problems were not related to not being able to perform tasks but for instance to wrong authorization leading to wrong clients in the caseload. But some complaints clearly indicate potential improvement in the design of the training. For examples, several users complained some actions did not work while they simply needed to refresh the page they were working on. While this information was provided in one of the course modules it was clearly not practiced enough to be remembered in the working context.

4 DISCUSSION

Large organizations regularly face new versions of software applications. Especially when all employees of an organization use a specific application and both the old and new version of the application cannot be supported concurrently, the organisation is confronted with a major training challenge. This study explored the effects of an e-learning solution for large-scale software training when large numbers of employees need to be trained on short notice. Our research question was: *Is a contemporary (i.e., didactically and technologically sound) e-learning method for software training effective and more efficient than a customary classroom training method?*

A state-of-the art e-learning solution was developed since the regular training approach (a two hour classroom session for a maximum of 15 people) was not an option. The e-learning solution was founded on contemporary instructional design principles, like the whole task approach (cf. Van Merriënboer and Kirschner, 2013). First, this study explored the (perceived) effectiveness of the e-learning solution in order to be able to conclude that contemporary, didactically sound, e-learning courses can be given preference to classroom training and traditional e-learning solutions (i.e., the 'computerized page-turners'; cf. Jochems et al., (2004)). Results of the questionnaires of the superusers indicate that the e-learning courses and tests were effective and a large majority of the superusers stated that the courses are well suited for learning to use (updated) EMR software.

Analyses of the time on task of participants who finished their e-learning course showed that participants managed to finish the course within an hour and a half on average, which is less than the expected two hours. In addition a high percentage of the participants passed the concluding test, which proved they gained the knowledge base necessary to use the EMR software for daily professional tasks. Also the effectiveness of the e-learning solution as perceived by the group superusers turned out to be positive. A total of 78% of the superusers concluded that the e-learning courses were ideal for training an upgraded version of the software.

The e-learning was designed using a "just enough" principle and succeeded in training the tasks users applied often in a time-efficient way. Ideally the learning is continued on the job using available online help facilities. However current online help does not take a task perspective but provides information on system commands and data structures. A more intelligent solution based on task recognition and active coaching (Breuker et al., 1987) might be more effective but this is still a topic for future research and development (Delisle and Moulin, 2002).

The e-learning solution proved to be effective and should be given preference to classical software training methods. Contemporary (open source) tools for developing the e-learning courses turned out to be useful and effective (cf. Dewever, 2006; Godwin-Jones, 2012). In addition, using present-day instructional theories for guiding the instructional design (Merrill, 2002; Van Merriënboer and Kirschner, 2013) contributed to good quality e-learning courses (as perceived by the participants).

For future research we propose two strands of research. The first strand aims at optimizing the quality of the e-learning courses. In order to improve the instruction for coming Psygis Quarant software updates, an educational design based research approach (McKenney and Reeves, 2012) will be used. The second research strand aims at generalizing findings. Since the results of the present study are based on a single case in one domain, it is our intention to replicate the design based research approach in other domains as well.

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SHORT PAPERS

Competences for the Music-Technology Context on the Distance Learning

A Focus in the Use of Online Digital Technologies

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Keywords: Distance Learning, Music Composition, Digital Technologies.

Abstract: This article presents a case study about the competences for the music-technology context on the distance learning from the use of online digital technologies. Although most of these tools haven't been developed for educational purposes, this paper reports their use over education. The article also aims to map the necessary competences for students, teachers, musical tutors and outsiders in music to create their own musical digital compositions for their digital educational materials (DEM). The results of the research are presented in the end.

1 INTRODUCTION

Given the arrival of web based Technologies, especially the free ones, musical composition becomes available for either musicians or outsiders in music. Thus, it may be implied that it is no longer necessary to know how to play a conventional musical instrument to virtually create music, since computer performs this action. According to Iazetta (2009), in accordance to Fritsch (2008), computer encompasses the functions of the musical instrument, amateur studio and performer, "[…] merging the separation of singing, listening and composition" (Iazzeta, 2009, p.158).

When treating about digital Technologies, Palfrey and Gasser (2011) say that they have been used in various fields of knowledge and with many functions in the society. Professionals need competences to perform on a more computerized world. According to the authors, due to the possibilities provided by the internet, there are indications that there will be extraordinary digital masterpieces[2] made by the Digital Native in the future. However, at the same moment that these new digital forms of art appear, there is a growing concern with the cyber culture of "[…] 'cut, mix and burn' (a CD or DVD) […]" (Palfrey and Gasser, 2011, p.146).

In accordance to Palfrey e Gasser (2011), Ribeiro et al. (2011) points out that the use of Web 2.0 tools may help in the creative process, once people create and interact on the contents of the web, by sharing intellectual productions, experience, information, etc. in Weblogs, Wikis, social networks and others.

However, according to Behar et al. (2013), the mere use of these tools does not assure a quality final product or excellence on the teaching and learning process. For the author, in order to have quality Distance Learning those who wish to compose through digital technologies need to build knowledge, competences and attitude. This way, they will be able to perform properly in the music-technology context. By means of a study[1], it was tried to check what are the necessary competences for students, teachers and tutors to perform in the educational music-technology context. This research, which will be detailed in section 4, had its focus on online digital technologies with the use of computer. Those herein described are consisted of available resources at the internet, such as learning objects (LO) and the digital music tools dedicated that present the features of the Web 2.0. One of these features is the creation and sharing of own compositions. Online tools are software whose storage and sharing occur at the internet, also known as cloud computing. These resources have been used in the educational context, especially in the Distance Learning.

In the section 2 of this article, the factors that influence the development of competences for music are presented, as well as the concept of musical composition and its relation to creativity. On section 3 the online resources are presented as learning objects, used as theorical and didactic support either for distance learning or presential courses and subjects. Section 4 is regarding a case study to investigate the *educational* music-technology competences, developed upon the use of the Web 2.0 tools. In the end, the final remarks are exposed on section 5.

2 COMPETENCES FOR MUSIC: A FOCUS OVER THE DIGITAL MUSIC COMPOSITION

Tafuri (2008), in accordance to Hargreaves (2000) and Stefani (2007), emphasize the importance of the people's interactions with the social, cultural and educational environments, for the development of competences for music.

Besides the influence of the social and cultural environments, Hargreaves (2005) and Tafuri (2008), state that self-confidence may be primordial for the development of musical skills. For Dörge (2010), besides self-confidence, creativity, flexibility and autonomy are considered fundamental for the development of competences. For Tafuri (2008), the way individuals notice and construe the information on the way to their brain depends on the knowledge, interest, attitude, personality, self-confidence, temper, and others.

Behar et al. (2013) is favorable to Tafuri's (2008) and Hargreaves's (2000, 2005) ideas about the importance of the social, cultural and educational contexts for the development of musical competences. The author also agrees with Peretz (2006), who included the genetic influence. However, competences are more than competences, capacity or aptitude. It is understood, according to Zabala and Arnau (2010), as the mobilization of these elements, according to one's experience, psychological, cognitive and emotional formations in the social context where they are inserted.

2.1 The Musical Composition and its Relation to Creativity

According to Araújo (2006), on an attempt to find and identity for the teaching profession, came the need of specifying what are the knowings directed to the musical domain in the teaching and learning processes. The possibilities provided by the Web 2.0 allowed the exchange of information among students, tutors and teachers on a virtual environment and access to repertoires of many ages, styles and genres. Besides the download option and the listening of the musical repertoires at the web pages, it is possible to create your own digital media, integrating sounds, texts, images, songs in videos, presentations, etc.

Ribeiro et al. (2011), in accordance to Araújo (2006), claim that the social software of the Web 2.0 enable people to create, putting to practice learnings that were not possible before these technologies existed. For the author, the use of these tools may help in the creative process, since individuals create and perform over the web contents, taking advantage of the public intelligence. In accordance to these authors, these creative practices also occur in the musical composition with this type of software and are a result of a creative process of the individuals.

When referring to musical composition, Webster and Hickey (2009), Maffioletti (2005) and Guterres (2012) are favorable to the use of this practice as a pedagogical activity for the teaching of music. Guterres (2012) point out that the musical composition is a "make to understand" the musical contents. Webster and Hickey (2009) mention that

> [...] in addition to the growing interest in improvisation and its role in musical development, compositional thinking as a strategy for teaching music has become a major force in countries such as Australia, the United Kingdom, and the United States. (Webster and Hickey, 2009, p.379).

According to Ribeiro (2011) the use of Web 2.0 tools may help in the creative process, since individuals create and perform over the web contents, taking advantage of the public intelligence. Araújo (2006) and Palfrey and Gasser (2011) claim the possibility of new forms of art coming from Native Digital individuals. Linking to these authors, it is possible to make creative music pieces through digital online tools. These tools will be exposed in the next section, and the online digital resources produced for the Distance Learning as well.

3 ONLINE DIGITAL TECHNOLOGIES RESOURCES AND TOOLS FROM THE WEB 2.0 THE DISTANCE LEARNING

According to Fritsch (2008) the synthesizers were developing in a way an only one musician may compose in studio, perform and be the only audience of their own songs. These instruments are currently found virtually on software.

Given the above mentioned, the computer is the composition and execution instrument and the studio as well. With this facility, Webster and Hickey (2009) show that technological resources may help music teachers on many contents. They have a quick review over the studies that have been using this technology for reinforcement and comprehension of the music education related aspects.

> We believe that this use of music technology can be a powerful aid for music teachers to reinforce, extend, and refine the expected development of music perception, performance, preference, and creating […] (WEBSTER; HICKEY, 2009, p.383).

Authors classify various software according to: type, music content and age, from pre-school up to the adult age level. Among these authors, they point out the Vermont Midi Project for music creation. This project was pioneer using internet to facilitate musical collaboration.

On their conclusions, they point out studies that consider the use of music technology helps comprehending, which advances the development process of music learning and understanding in those that use it.

Behar at al. (2013) shows other software examples for the collaborative distance music composition programs, such as `Music-COMP`[2], used in the United States. In the educational context, the author also mentions `Musit Interactive` and `jam2jam`. According to Seddon (2007), the former allows sharing the created music files, facilitating the social exchange among the participants. The latter, `jam2jam`, is a web based system for improvising, with functionalities that favor social interactions. (Brown and Dillon, 2007).

Hodges (2001) points that the Information and Communications Technology (ICT) includes "all forms of computer-based learning, and recognizes the importance of the Internet and associated communication technologies." (Hodges, 2001, p.170). As for the use of technologies in teaching, he mentions about the importance to make a distinction between training and education. It becomes necessary because there is a difference between skills acquisition and conceptual understanding.

Another example that uses ICT in music education is mentioned by Smith (1999), in the secondary PGCE music course at Kingston University. A partnership between "training providers and schools" has been made, because the music technology needs to be contextualized with the classroom and not just developing skills. She sustains there is a better approach between "educational theory and its application." (Smith, 1999, p.197). In this music course "including delivery of music technology, has acquired an increasingly holistic emphasis." (Smith, 1999, p.197).

Savage (2007, p.65) sustains that technologies "are transforming approaches to teaching and learning in primary and secondary schools." The author mentions that especially within the field of music education there were changes. In spite of having a substantial range of new technologies, their use was limited due to the fact that it is linked to the traditional composition and performance.

Seddon and Bisutti (2008) researched about non-music specialist teachers. According to the research, non-music teachers usually present low-confidence to teach music in primary education. It may be explained because of the belief, especially in the western culture, that success in music requires inner talent.

In their conclusions, after the interaction with an e-learning environment teachers noted that music is not something special, only for gifted individuals. Thus, there is a break on the "cycle of low expectation" and the non-music specialist can provide opportunities to children to engage in creative musical activities in classroom. (Seddon and Bisutti, 2008, p.418).

As indicated by Behar et al. (2013), there are several online tools in open source for the musical composition that, although not being developed for educational purposes, have been used with this purpose.

Tools as `Jamstudio`, `CODES`[3], `MusicLab`[4], `Tonematrix`[5] and others have been used in extension courses in semi-presence and distance learning subjects at Universidade Federal do Rio Grande do Sul (UFRGS).

According to Behar et al. (2013) besides these available tools at the Web, online digital resources have been in development for the Distance Learning. Among them are the Learning Objects (LO) developed by interdisciplinary teams at the Núcleo de Tecnologia Digital Aplicada à Educação (NUTED).

Among the LO presented on section 3.1, the object Digital Music Composition – CompMUS[6] – will be detailed, since it was used in the case study on the present approach, aiming to map the competences for the music-technology educational context.

3.1 CompMUS: A Learning Object for the Digital Music Composition

The CompMUS LO is an example of an online digital resource used in Distance Learning, whose purpose was to serve as a theory/pedagogical resource for the mapping of competences for the music-technology educational context.

CompMUS was developed in accordance to Amante & Morgado's (2001) methodology, which involves four steps: object conception, planning, implementation and evaluation. This object was developed by an interdisciplinary team, where the authors also participate. This object show 4 modules. Each module refers to an issue pursuant to the digital musical composition.

In modules 2 and 3 of this object have activities involving musical composition through `CODES`, `MusicLab` and `Jamstudio` tools. For the effect application and edit, the software Audacity is recommended. The digital interactive tools `Tonematrix` is found in module 4. The activity in this module consists of creating a podcast episode in pairs. It must have educational content and a soundtrack composed by the authors of the podcast using one or more online digital tools.

4 THE MAPPING OF COMPETENCES FOR THE MUSIC-TECHNOLOGY CONTEXT: A CASE STUDY

Aiming to investigate the competences for the music-technology context from the musical composition with the use of free digital tools, the case study was performed by an extension program course.

This course, named identically to the LO CompMUS: Digital Musical Composition for Education, was one of the tools used for the data collection.

The classes occurred in semi-presence and distance basis, with 80 hours' workload, on a weekly basis from April until June 2012. Two online questionnaires were applied, the first one to get information over the student's profile, their knowledge and experience in the music and technological fields; the second one was to evaluate the course and the LO. In order to register the testimonials and students' compositions the virtual learning environment (VLE) Rede Cooperativa de Aprendizagem (ROODA)[7]was used.

Besides the use of the CompMUS LO as theory/pedagogical support resource during the classes.

The participants of the course were teachers from the public teaching network from various levels, music teachers, tutors, pedagogy and music students, post-majoring course students and Masters in a total of 17 students, where 9 were music teachers and 8 non-musicians.

As previously mentioned, the aim of the course was to develop a mapping of the necessary competences for the intended context. According to Brandão and Guimarães (2001), it is a technique linked to the knowledge management based on the staff and their functions. As for the function of this methodology, it is noticed a search for the identification of the already existing competences and the development of the necessary ones for an intended profile on a determined context.

Besides the main target, the study also aimed to investigate the profile of the participants of the research; the knowledge and prior experience of students about the technology and musical areas; analyze how they organize the sound material when compounding virtually and how CompMUS LO contributed to the development of competences for the intended context.

Based on the data collected, a concept map of the competences individuals shall develop for the music-technology context has been developed based on the results found, and is indicated on table 1.

However, it is proper to mention that many of these competences form were developed by the individuals during the extension course.

The importance of the development of instrumental performance and the Study of Theory and Musical Perception for the construction of specialized competences, inherent to professional musicians, is understood. Nevertheless, we emphasize that the competences listed are general ones, meaning they may be constituted by outsiders in music.

5 CONCLUSIONS

From the experiment performed, we understand that the use of digital online tools, as the ones used in this study, used on an integrated basis on virtual learning environments as well as learning objects, have potential to support in the development of competences for the music-technology context on

Table 1: Competences for the music-technology context from the use of digital technologies. Source: (Rosas and Behar, 2012, p.8)[8].

KNOWLEDGE (K)1	**SKILLS (S)**	**ATTITUDE (A)**
- Know various audio formats	-Make and compound digital music in a public/ collaborative way;	- Opening to new sonorities provided by the digital technologies;
- Know effects for audio treatment;	- Convert audio format, liable of internet transmission;	- Self-confidence;
- Know the historical pressupositions of eletroacustic music;	- Setup the computer soundboard according to the operational system, the software and digital musical tools to be used as well;	- Capacity to motivate yourself and motivate others;
- Notions of simple music form and structure;	Use online, specially free software and tools for musical composition and production;	- Proactive (capable of controlling the structure and content on the CMD);
- Read and interpret virtual and multimedia messages;	- Use free software for audio recording, editing and mixing;	- Flexibility for changes;
- Notions harmony and chords ordination on the western tonal system to organize the sounds at musical digital composition;	- Use Information and Communication Technology (ICT);	- Be responsible for the ICT use;
	- Install and uninstall musical software;	- Autonomy;
		- Opening to several musical languages, from classical, pop to contemporaneous.

Distance Learning. The knowledge, skills and attitude herein presented may be built by teachers, students and music tutors who own little or no experience within these technologies or by teachers and students outsiders in music, who wish to perform on this context, with or without prior technological experience.

When making the competences mapping, besides observing those existing and pointing out the necessary ones, it was found that part of the knowledge and competences presented on table 1 were developed at the moment their compositions were being created, when interacting with CompMUS, with the teacher and the classmates over the VLE (Virtual Learning Environment) during the classes.

We believe continued education courses are necessary, in order to prepare these individuals to perform on this context, developing knowledge, competences and the necessary attitude for the music-technology context.

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1 Case Study at the Post-Majoring Program in Education at Universidade Federal do Rio Grande do Sul, Brazil.

2 *Music Composition Online Mentoring Program*. Retrieved from: http://www.music-comp.org/.

3 Cooperative Music Prototype Design. Prototyping refers to musical creation. According to Milletto et al. (2005) this expression is not known in the music area and was used to highlight the differences between compositions made by musicians and the experiments and creations made by outsiders in music.

4 http://clubcreate.com/#!/studio/musiclab

5 http://lab.andre-michelle.com/tonematrix

6 http://www.nuted.ufrgs.br/objetos_de_aprendizagem/2011/CompMUS/

7 https://ead.ufrgs.br/rooda/

8 Table translated by authors.

Capitalize and Share Observation and Analysis Knowledge to Assist Trainers in Professional Training with Simulation

Case of Training and Skills Maintain of Nuclear Power Plant Control Room Staff

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Keywords: Modelled Traces, Transformations, Exploration Trace-based Systems Framework, Full Scope Simulator, Observation and Analysis Help, Training, Nuclear Power Plant, Share Knowledge.

Abstract: The observation and analysis of the activity of learners in computerized environments training is a major issue, particularly in the context of professional training on nuclear power plant full-scope simulator. In such a context, the role of the trainers is critic and require constant alertness throughout the simulation especially for the young trainers. The objective of our work is to propose an approach to facilitate the observation and analysis of the trainees' activities. This approach is based on interaction traces. It consists in representing the operators' actions and the simulation data in the form of modelled traces. These modelled traces are transformed in order to extract higher informations levels on the behaviour of trainees. Trainers can visualize the different levels to analyse the reasons, of successes or failure of trainees. This approach has been implemented in a prototype, called D3KODE, allowing the representation, processing and visualization of traces. D3KODE was evaluate according to a comparative protocol conducted with a team of trainers from EDF Group.

1 INTRODUCTION

This work addresses the general question of observation and analysis of learners' activities in a situation of professional training. More specifically, we addresse the case of full scale simulators (FSS) designed to maintain and enhance the knowledge and skills of Nuclear Power Plant (NPP) control room staff (Champalle et al., 2011) (Blanc et al., 2010). In this context, the observation, analysis and debriefing of individual and collective interactions of trainees is a dense activity that require attention and constant alertness of the trainers throughout the simulation.

Indeed, during each simulation session, the instructor runs the simulation scenario, observes behaviour of trainees, drives the simulator based on the actions performed by trainees and fills an observation balance sheet to prepare and conduct the debriefing. Observation balance sheet contains a set of expected operations that trainees should be able to satisfy (see for example the Annexe G of (Agency, 2004)). These operations correspond to the knowledge and skills that are necessary to insure safety of the plant.

To assist trainers in their tasks, the NPP FSS possesses several tools to follow, record and replay the parameters of the simulator and the actions of the trainees. These tools have however their limitations:

- The data stored in the logs are very low level. In such a context, understanding and following the activity require a strong expertise that all trainers don't have;
- The amount of data collected during a simulation is so big that it is very difficult to analyse them manually and extract high level information reflecting the behaviour of trainees;
- The synchronization of these different types of data (video, sound, logs,...), is difficult and expensive. Indeed, the data are stored in different places and files and do not share the same time line.

With the aim of going beyond these difficulties our proposals are the following:

- assist trainers in observation and analysis of activity by:
  - providing a visual synthesis of the activity with the expected observations of the trainees (realized or not realized);

  - allowing exploration of the abstraction levels to facilitate the analysis of the activity;
  - allowing trainers to add their own observations corresponding to their expertise to save time during the phases of observation and analysis.
- strengthen the debriefing by:
  - providing trainees a visual synthesis of their activities in a self-reflexive way;
  - providing trainers factual information to exchange with the trainees.
- favour sharing of observation and analysis knowledge between trainers by:
  - allowing trainers to exchange on their practices;
  - allowing new trainers to reuse the knowledge of the confirmed trainers.

To improve the actual tools for trainers and concretize our proposals we base our reflections on a better exploitation of simulation data.

This article is organized as follow: section 2 presents a state of the art on related works. Section 3 presents our approach, models and tools for observation and analysis activities. Section 4 present the evaluation of our approach and the results. The last section is devoted to a conclusion and perspectives.

2 RELATED WORKS

Exploitation of the trace of trainees' activities is a spread practice in the computerized dedicated environments for training. With the term Digital Traces we mean all numerical data produced by an activity or set of activities. These activities result from human system interactions and/or between a system on another system.

In order to find the most relevant approaches for our proposals, we have conducted a state of the art in two steps. At first we have compared approaches close to our context and research proposals. In a second step, we focused our study in the field of knowledge engineering to determine the approaches best suited to capitalize knowledge from observation and analysis of the activity, whatever it is.

Approaches on Similar Research Context

In the domain of Nuclear Power Plant Full-Scope Simulator, the SEPIA system (Dunand et al., 1989), a computer training system by artificial intelligence, was designed for operators training of EDF Group on pre-defined scenarios. SEPIA is based on an expert system constructed from the knowledge of driving procedures and expert trainers. Once the simulation over, SEPIA gives a feedback by analysing and correcting the operators' actions. During the debriefing, SEPIA allows the operators to obtain explanations concerning any registered parameters.

In Aircraft simulation (IIPDSS), (Bass, 1998) introduces an intelligent trainer pilot decision support system that use trace of trainee-pilot' activities to help trainer during the simulation, debriefing, and performance evaluation. During the practice, the system displays in real time to the trainer a list of message to help him understand and guide the trainee. For the evaluation, the system collects and displays the evaluation criteria applicable to a particular simulated mission and instances when the trainee failed to meet the criteria. At the end of the simulation, the system provides a complete trace of the divergent actions of the trainee, associated with the corresponding data of the aircraft simulation environment. The system provides also a summary of the skills with which the trainee has difficulty.

The PPTS project (Pedagogical Platoon Training System) (Joab et al., 2002) assists trainers to observe and analyse the tactical behaviour of a platoon network of four LECLERC tank simulators. The PPTS integrates an ITS which reproduces the expertise of trainers in order to exploit and analyse the numerical traces of the simulation to highlight the three skills levels expected from each crews: technical, tactical and strategic. Each level being constructed on the basis of lower level. At the end of the simulation, the PPTS generates a summary document and comment on the skills of the crews to assist trainers in the debriefing phase.

Works cited above use the digital traces of activity to diagnose and analyse behaviour of trainees but miss important properties. Indeed, the tools proposed in these approaches are based on closed systems. Their implementation is generally heavy (ITS, expert system) and requires a long and close collaboration with experts. Another limitation lies in the "static" knowledge used by these systems. Indeed, once these systems are built, it is not possible for the trainers to create and share their own observation and analysis knowledge. It is also not possible to define the levels of expected skills.

To meet this specific need of creation and sharing of observation and analysis knowledge based on digital traces, we studied other approaches from knowledge engineering.

Knowledge Engineering

(Dyke, 2009) proposes the analysis tool Tatiana (Trace Analysis Tool for Interaction Analysts) which implements the concept of *replayable* in order to assist the analysis of heterogeneous data (videos, logs, ..). A replayable is a generic analytic artefact that models and capitalizes an analysis methodology built from user trace. A replayable can be visualised, replayed, enriched, transformed to produce a new replayable and synchronised with other like artefacts.

The system ABSTRACT (Analysis of Behaviour and Situation for menTal Representation Assessment and Cognitive acTivitiy modeling)(Georgeon et al., 2011) is used to analyse human activity from successive transformations of low level trace. Transformations are based on SPARQL rules and can be reused in different contexts. Abstract provided the possibility to visualize traces and their transformations.

The TBS-IM (Trace Based System Indicators Moodle) (Djouad et al., 2010) allows the creation of individual and collective indicators for educational activities on the learning platform Moodle. TBS-IM supports the user in the elaboration of indicators masking successive abstraction levels necessary for their construction. These indicators calculations can be capitalized for the purpose of reuse.

These approaches are similar to our research objective. Their advantage lies in the common use of the concept of *Modelled Trace* (see Section 3) and the principle of reuse of transformation for abstracting a low level trace in order to highlight higher levels of knowledge. There are however differences and limits. In (Dyke, 2009), there is nothing to assist the trainers in the creation of the transformations rules, TBS-IM (Djouad et al., 2010) can not view the activity on different levels of abstraction and ABSTRACT (Georgeon et al., 2011) does not allow transformation with several rules.

If these approaches do not fit all the searched properties, the approach based on modelled trace and transformation rule, enhanced in ABSTRACT and TBS-IM, seems to be more flexible, facilitating the analysis and knowledge sharing.

3 CONTRIBUTIONS

Our research is based on the concept of modelled trace developed by the SILEX[1] team (Settouti et al., 2009). A Modelled Trace, noted *M-Trace*, is a set of observed elements associated to the trace model itself. We call observed element, noted *obsel* any structured information generated from the observation of an activity (Georgeon et al., 2011). In our research context, activity observed is a training simulation on a NPP FSS of EDF. The obsels collected are the result of users interactions (trainees and trainers) with the FSS, and the simulation of the NPP process itself. Formally, each observed element has a type, a label and a time stamp in the M-Trace. According to his type an obsel can have a set of attributes/values, which characterizes it. An obsel can potentially be in relation with other obsel of the same M-Trace through *relation type* defined in the Trace Model. The Trace Model defines the types of observed elements (i.e the attributes that characterize them) and the types of relationships they can have between them. A Modelled Trace is then a structure of data (obsels and relations) explicitly associated with its trace model. Modelled Traces are managed with a Trace-Based Management System (TBMS) (Settouti et al., 2009). The TBMS is responsible for managing the storage of traces (rights management, database...) and their transformations. A Transformation process performs transformations on M-Traces like applying filters, rewriting and aggregating elements, etc. so as to interpret and abstract M-Trace.

Visual Synthesis of the Activity

For reasons we have explained above, the data collected by the simulators are difficult to analyse. It's why we distinguish three levels of m-traces:

- Primary M-Trace whose obsels arise from data collected by the sources of the simulator;
- M-Trace of Pedagogical Objectives, which represents the first level of expected obsels that trainees have to realize and trainers to check;
- M-Trace of Pedagogical Objectives Family. This higher M-Trace shows obsels that describe ”pedagogical objectives family” (realized or not) as expressions of the expected trainees' capacities.

These different levels of M-traces are obtained by applying rule-based transformations. These rules makes explicit the observation knowledge of expert. As shown in figure 1, each obsel belonging to a trace of level n is in relation with its origin obsel(s) from the trace of level $n-1$. The obsels of the Primary M-Trace are in relation with the data collected by the simulator. Such structure allows trainers to explore, analyse the trainees' activities with a top-down investigation to understand the reasons, be they individual or collective, of failure. Consequently, trainers would also be able to better prepare and conduct the

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[1] http://liris.cnrs.fr/silex

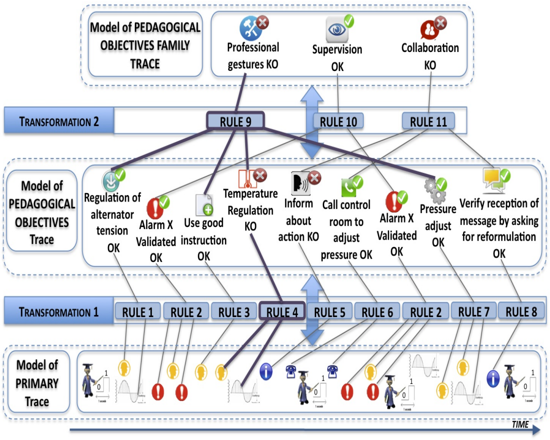

Figure 1: Principle of analysis by transformation and visualization of trace.

session's debriefing with trainees. On the other hand it would be possible to help new trainers to improve their skills by helping them in observing Trainees. For example, if the trainers want to understand the reasons why the obsel "Professional Gestures" of the M-Trace of Pedagogical Objectives Family is KO[2], they have just to navigate through their different origin obsels of the M-Trace of Pedagogical Objectives. According to the Rule 9, the obsel "Professional Gestures" is OK only if all of these four origin obsels are OK.

Generic Trace Model

Whatever the level of M-Trace, its model and the simulator used, we believe that a simulation M-Trace must "pick-up" its own identity to be locatable and usable over time. This "identity card" of the M-Trace would be particularly useful for large-scale statistical research and/or analysis on a set of M-Trace corpus, and particularly to feed experience feedback, described in the Trace-Based framework presented in (Champalle et al., 2011). Through experience feedback, trainers try to understand good or bad practices on several simulations in order to improve contents of the future training courses.

So, as described in the class diagram of Figure 2, all the M-Traces of our model have an ID, a beginning and end date, the level of M-Trace (Primary, Pedagogical Objectives,...), type of simulator, type of training (Initial or Retraining), category (Summative, Formative), with the scenario of simulation and the training program (Op Reactor, Op Turbine,...). In our context, the obsels are the direct result of users' interactions (trainees and trainers) with the FSS, and the message of the NPP simulation process (Primary M-Trace) or result from execution of transformations (M-Trace of Pedagogical Objectives and M-Trace of Family Pedagogical Objectives). Therefore each obsel type has common attributes: an ID, a begin and a end date, a label, the ID of the Generative subject (Person, Group, Simulator), a SubjectNature (evaluated or not), the RoleSubject (Op Reactor, Op Turbine, Supervisor, etc.) and a realization attribute (OK or KO). This model can be specify for each M-Trace model and obsel as needed.

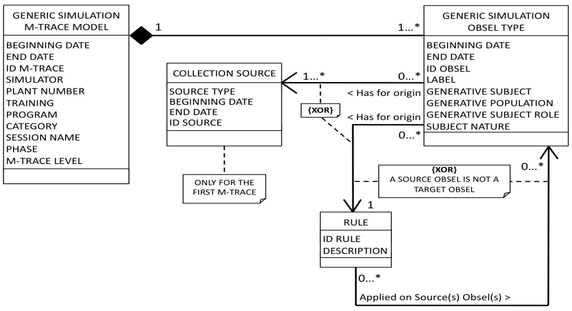

Figure 2: Generic Trace Model.

Transformation Model

Transformation allows generating a target trace of level n from a source trace of level n-1. Each Transformation is composed of a set of rules which have a part *Condition* and a part *Construction* (Figure 3). The condition part expresses constraints on the elements (obsel type, relationship type, values of attribute, etc.) of the M-Trace(s) source(s).

The construction part allows defining the obsel and the relationships of the new target M-Trace if all the constraints of the condition part are satisfied. For each part of a rule (condition and construction), it's possible to use specific operators as arithmetic, boolean and/or comparison in order to express constraints on the attribute values of sources obsels (condition) or make calculations to initialize the values of the attributes of the obsel target (construction).

D3KODE

D3KODE as "Define, Discover, and Disseminate Knowledge from Observation to Develop Expertise" is a Web application, which stores and transforms traces according to the organization and the models presented in previous sections. D3KODE also allows the user to interactively view the various trace levels. So the trainers can explore the different abstraction levels in purposes of investigation and/or education to target gaps and difficulties of each trainee.

The storage of M-Trace and transformation models and rules is based on the kTBS (kernel for Trace

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[2] The operator did not validate this objective

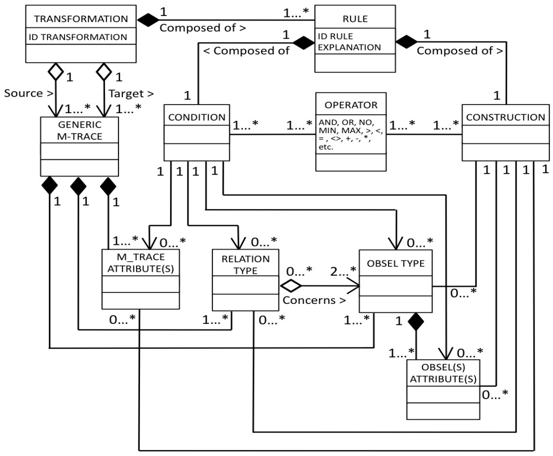

Figure 3: Transformation model.

Base System). The kTBS[3] is a Trace-Based Management System architecture (Settouti et al., 2009) developed by the SILEX team. Data of the kTBS are encoded in RDF[4] (Resource Description Framework). The transformation rules, are written in SPARQL1.1[5]. D3KODE is multi-user and multi-language.

4 EVALUATION AND RESULTS

In order to evaluate the properties of our approach we have defined an evaluation protocol based on a qualitative comparative method (Per and Martin, 2009). It consists in comparing the observation, analysis and debriefing of the trainees' activities with and without D3KODE. This evaluation was driven on a summative scenario on a FSS of an NPP of EDF Group. It mobilized 8 people: 2 confirmed trainers to drive the simulation and observe trainees, 4 trainees to drive the simulator (2 for each simulation) and 2 experts to observe the simulations and to assess the support provided by D3KODE. The trace models and transformation rules of the scenario were modelled by an expert trainer who did not attend the evaluation. In this way, we ensure the correct evaluation of the sharing of knowledge between trainers.

Simulation with D3KODE

The first simulation lasted 1 hour and 14mn and generated 3591 obsels which were collected and injected into D3KODE. The trainers have observed 2 No Realizations (NR) tracked in the simulation logs and viewable by D3KODE.

During the analysis, the obsels displayed by D3KODE were faithful with the simulation. Nevertheless, their visualization, did not bring more information to trainers. They have however considered valuable and useful the quick access to information such as begin and end date, obsel's label, rule's description, etc. This possibility has facilitated the analysis and exchanges between trainers. The presence, in D3KODE, of the 2 NR was a significant contribution for the trainers. No Realization are indeed what is traditionally harder to be confirmed.

During the debriefing, D3KODE was used by trainers as a visual aid to re-trace the chronology of observation and exchange with the trainees. During this phase D3KODE has also helped to highlight a NR which was "forgotten" by the trainers.

Traditional Simulation

The second simulation lasted 1 hour and 13mn. According with the evaluation protocol, D3KODE wasn't used for analysis and debriefing. During this simulation, The trainer have observed 3 No Realizations (NR) tracked in the simulation logs. The analysis and debriefing phase of the operators took place in much the same way that the simulation 1.

Global Analysis of the Results

The analysis of the results allowed us to collect several remarks on the contribution of D3KODE.

First of all, the trainers, showed themselves particularly interested in the visual synthesis of the activity on several levels. It would allow them, in the phase of analysis, to compare and verify the observations noted during the session, in order to be sure that nothing has been forgotten and so to raise all ambiguities. In this way our proposal concerning the revealing of observable KO was very relevant.

This evaluation also confirmed that the approach of D3KODE, based on rules and transformations in order to share knowledge of observation and of analysis, was understood and validated by all trainers. They have also validated the interest of our approach for the creation of additional specific observation (outside of the balance sheet of the evaluation) to attend their analysis and decision on the conduct of trainees. D3KODE would be used for post-analysis and calculations that trainers can not do in real time and/or analysis.

For the phase of debriefing, the essential contribution of D3KODE lies in the factual data presented through the visual synthesis of the activity. This functionality is indeed considered by the trainers as a good mean to encourage the reflexive self-analysis of the

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[3] http://liris.cnrs.fr/sbt-dev/ktbs/

[4] http://www.w3.org/RDF/

[5] http://www.w3.org/TR/sparql11-query/

trainees and highlight the axes of improvement.

Globally, the evaluation of D3KODE in real condition demonstrated that the trainers considered the contribution of D3KODE as relevant to enrich their activity. In particular D3KODE could strengthen the current tools of the follow-up and the analysis of the trainees' activities mainly a posteriori.

To wider scale, D3KODE would be even of a particular interest to analyse traces of simulation in quantity to highlight the recurring errors of the trainees and integrate them to the EXperience Feedback and build new more adapted trainings.

It should be added that if the trainers perceive D3KODE as potentially beneficial, they have pointed out that the use of D3KODE would introduce a change in their practices.

5 CONCLUSIONS

This article addresses the problem of observing and analysing trainees' behaviour on Nuclear Power Plant Full-Scope Simulator. This work, conducted in partnership with the UFPI of EDF Group, is applied in the context of training and maintaining the knowledge and skills of NPP control room staff. The objective of our work is to propose models and tools to help trainers capitalize and share their observation and analysis knowledge in order to improve observation, analysis and debriefing of trainees' activities during formative/summative assessment.

The approach we proposed is to transform the raw traces, based on data collected from the simulator, in order to extract high level information on the activities of trainees. For this we have proposed a dedicated trace model and transformation. In order to guarantee the exploration between various levels of M-Trace, each obsel possesses a link on its origin.

We have also developed a prototype, called, D3KODE which favour share of trainers' observation knowledge, and which stores, process and visualize the traces. This prototype implements the various models we have created. So as to validate our approach, we have conducted an evaluation based on a comparative method. This experiment was conducted with a team of trainers from UFPI of EDF Group in a real context. The result of the evaluation demonstrated that our approach was favourably welcomed by the trainers and could be really relevant to enrich their activity.

Our future work will aim to address the second objective of the project: exploitation of traces for the experience feedback to refine the needs and optimize training programs for years to come.

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POSTERS

Designing Workplace Learning and Knowledge Exchange
A Postgraduate Training Program for Professionals in SME

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Keywords: Further Education for Small and Medium-Sized Enterprises, Enhancing Internal Company Training, Blended Learning, Informal Learning, Virtual Classroom Sessions.

Abstract: In small- and medium-sized enterprises (SME) training requirements differ widely and can hardly be covered by broad training programs. For this reason these SMEs heavily rely on internal company training and informal knowledge exchange between co-workers to effectively use pre-existing resources like highly specific expert knowledge. To this end, professionals need to be trained in efficiently communicating their subject-specific knowledge as well as in realizing informal learning opportunities. Hence, in the postgraduate training program "Designing workplace learning and knowledge exchange" (aquwa) professionals are taught the necessary didactic competencies. The training takes place parallel to work over a 12-week period in a blended e-learning format. Modules 1 and 2 deal with principles and methods of knowledge exchange. These principles and methods are further elaborated in Modules 3 and 4, culminating in participants' independent development of an informal learning opportunity at the workplace. The evaluation of the training shows a great acceptance of the course design as well as a significant learning gain over time. Most of the participating professionals recognised a successful transfer of the gained competencies into their workplace. Based on participants' remarks suggestions for online-based postgraduate education courses are provided.

1 INTRODUCTION

In small- and medium-sized enterprises (SME), especially in those which provide highly specialised products and services, professionals are considered as an important factor for being innovative, and hence, for being competitive. As a result training requirements of such enterprises differ widely and can hardly be covered by broad training programs. The percentage of SME using further education is very small (Lenske and Werner, 2009). Reasons are a lack of resources. However, SME especially are more affected by demographical and cyclical based skills shortage than large-scale operations.

One possibility to tackle these problems is to maximize already existing personal resources in the company. The idea of the postgraduate training program "Designing workplace learning and knowledge exchange" (aquwa) is to show professionals how to teach their expertise to other employees. Thus, in aquwa, professionals are taught to communicate their subject-specific knowledge to co-workers more efficiently. Moreover, professionals become qualified to plan and conduct SME internal learning opportunities and to initiate and foster knowledge exchange within the company (cf. Desouza, 2003; Kyndt et al., 2009).

2 COURSE DESIGN OF AQUWA

The postgraduate training program aquwa lasts 12 weeks and consists of four modules. The contents are made available on a weekly basis. The program contains texts for self-regulated study which are accompanied by workplace-relevant group work, exercises, role-plays and other interactive interventions during virtual classroom meetings (see Table 1). Thus, participants are able to attend the training program while working fulltime.

Whereas a kick-off meeting and a closing event take place at the TU Dresden, the contents are conveyed completely online. This eliminates travelling time and also travelling costs for the participating SME.

Table 1: aquwa - a combination of text for self-study and virtual classroom sessions.

Texts for self-study
▪ Preparation for the virtual classroom sessions ▪ *Materials:* texts, illustrations, worked out examples, interactive exercises, videos
Virtual classroom sessions
▪ Content from the self-study texts are discussed and elaborated ▪ *Methods:* live-presentations, exercises in groups, case studies, role plays, discussions, coaching

2.1 Informal Learning

People learn at work by participating in various situations, collaborating with colleagues and clients, developing and testing new ideas, or meeting new challenges (Leslie et al., 1997; Tynjälä, 2008). These activities correspond to the term of informal learning. Furthermore, informal learning is considered as learning outside of educational institutions and without a specified curriculum (Eraut, 2004). Thus, the contents of the aquwa training programs are derived from theoretical and empirical findings on informal learning.

In informal learning settings learning arises from mastering new and unfamiliar working tasks (Stern and Sommerlad, 1999). One method to foster the learning success in informal learning is to enhance the support when working on an unfamiliar task (Overwien, 2005). Thus, the participants of the training program aquwa are taught competencies which are useful for preparing and providing such support.

2.2 Modules

The training program contains four modules. Module 1 and module 2 serve for participants' knowledge acquisition, whereas module 3 and 4 prepare and ensure transfer.

In Module 1 participants acquire knowledge on principles for preparing knowledge such as how to effectively communicate in written form, or how to design exercises to foster learning.

Module 2 presents participants with methods for knowledge exchange, for example to explicate tacit knowledge, to provide constructive feedback, or to moderate discussions.

All these principles and methods are important for professionals who want to exchange their knowledge because they represent facilities which can support informal learning. However, informal learning at the workplace is versatile so it is not necessary to use every method in every case. Professionals have to decide from case to case which principle and which method is most suitable for a particular learner in a specific situation. Thus, in module 3 the problem-oriented application of the principles and methods is addressed. Here, participants design and evaluate sample learning situations, or create pieces of instructional materials and exercises for given topics.

During module 4 participants by themselves develop an informal learning opportunity. This includes the generation of educational material and/or documents for the implementation of the learning opportunity at the workplace.

The four modules build upon each other. During the knowledge acquisition phase, participants practice the principles and methods taught in small exercises, in module 3 participants are required to apply a combination of the contents of module 1 and 2 to solve the presented problems. Finally, in module 4 the participants have to apply all their knowledge acquired in aquwa to design a complete, realistic informal learning opportunity. Thus, during the training participants are confronted with tasks of increasing complexity accompanied by decreased tutoring and scaffolding (van Merriënboer et al., 2003). By not only acquiring principles and methods, but also by applying them to problem-oriented and work-related scenarios, it is expected that participants do not acquire inert knowledge, but rather knowledge that can be used for effective problem-solving in realistic situations, finally leading to a successful transfer to the workplace (e.g., Eraut, 2004; see also Merrill, 2002).

2.3 Implementation and Participants

A pilot study started with 16 professionals from different SMEs in Saxony (Germany). 11 participants completed the program. Log-file analyses showed that on average every participant spend 75 minutes per week on the self-study texts and attended 9,5 of the 12 virtual classroom sessions.

3 EVALUATION METHODS

The training program was evaluated in accordance with an evaluation model by Kirkpatrick (1994).

To examine participants' reactions (level 1) a questionnaire was administered at the end of the program which assessed acceptance of the program and participants' satisfaction.

Concerning level 2 (learning), we conducted a knowledge test at three different times: before the start, after module 2 (knowledge acquisition phase), and after the complete training program. A problem-solving test measured how well participants are able to apply their acquired knowledge to new problems. This problem-solving test was conducted after module 2 (before the transfer phase), and after the training program was finished.

The knowledge test consists of one item for each topic of the knowledge acquisition phase. By choosing three different times of assessment, it is possible to measure the knowledge gain and the learning process of the participants. Moreover, it can be examined, if the content is learned in a sustainable manner and still available several weeks after the content was conveyed. Due to the small sample size, the results of the knowledge tests are analysed by the non-parametric Friedman test for repeated measures. Afterwards, detected differences are tested using the non-parametric Wilcoxon signed-rank test.

The problem-solving test contains 8 items in which all main topics of the training program have to be applied to new problems. In this way it can be tested if participants perform better after completing module 3 and 4 (transfer phase). Since the problem-solving test was conducted only two times the non-parametric Wilcoxon signed-rank test is used for the analysis, as well.

With regard to level 3 (behaviours), interviews were conducted within the participating enterprises 8 weeks after the training program was finished. The interviews concerned the transfer of program contents to the workplace.

Level 4 (results) was not assessed.

4 RESULTS

4.1 Level 1 – Reactions

The results of the questionnaire (scale from 1 (strongly disagree) – 5 (strongly agree)) are:

- The participants appreciated the online-conception (*M* = 4.45; *SD* = .69).
- Participants would participate again in program containing of self-study texts and virtual classroom sessions (*M* = 4.45, *SD* = .95).
- The contents of aquwa were work relevant (*M* = 3.80; *SD* = .93).
- The participants appreciated the instructors supervision during modules 3 and 4 (*M* = 4.45; *SD* = .69).

4.2 Level 2 – Learning

Figure 1 presents the results of the knowledge test at three different times and the problem solving test at two different times. The results are shown in percentage of the maximal possible score.

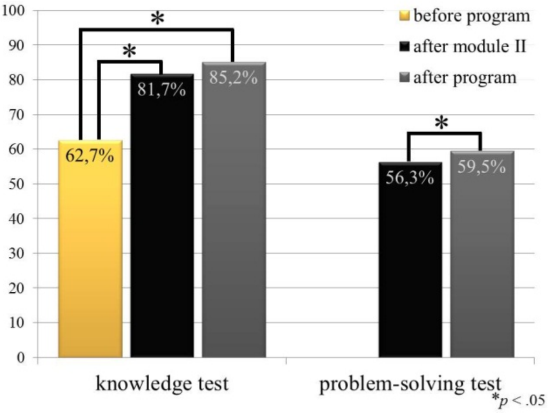

Figure 1: Results of the knowledge test and the problem solving test on three different test times (in %).

By conducting the non-parametric Friedman test a significant overall effect was observed (χ^2 (2) = 9.30, *p* < .01). Although, the participants presented a relatively high level of previous knowledge with 61,5% of the maximal score, the subsequent Wilcoxon signed rank test revealed a significant increase of knowledge after module 2 to 81,8% of the maximal score (W_S = 2.04; *p* = .03). Six weeks later, participants were still at the same knowledge level (85,2%), no significant difference could be observed (W_S = 1.07; *p* = .50). This result is completely in line with expectations that the increase of knowledge took place primarily in the knowledge acquisition phase (module 1 and 2).

For the problem-solving test two different test times were examined. The performance in applying the gained knowledge after module 4 was 9,85% higher than after module 2. The Wilcoxon signed-rank test revealed that the difference is statistically significant (W_S = 2.37; *p* = .02). The result confirmed the hypothesis that the ability of applying the before learned principles and methods could be improved after the transfer phase (module 3 and 4).

4.3 Level 3 – Behaviour

The interviews for investigating if the contents were transferred into the participants' workplace were conducted September 2012. The interviews lasted from 10 to 20 minutes. Nine of the 11 participants could be included. Participants' answers showed that

- eight respondents (89%) reported changes in their daily work due to their aquwa participation;
- five interviewees (56%) already realized an informal learning opportunity at their workplace after finishing the course (four of them were implemented very successfully; one professional did not complete the implementation yet);
- the other four former participants (44%) stated that there was not enough time in addition to their normal work volume to implement a learning opportunity.

5 CONCLUSIONS

All in all the results suggest that the postgraduate training program aquwa is a very successful e-learning program.

We were able to foster informal learning at the workplace. We tackled the problem of unsystematic knowledge exchange in SMEs successfully by providing professional with possible didactical approaches and methods for independently designing informal learning opportunities. Furthermore, this further education course took place completely online-based via an e-learning platform and meetings in a virtual classroom. We hold the view that neither the self-studying of texts via the platform, nor the trainings in the virtual classroom would have been as effective as the combination of these two elements. In this way the participants were independent and had full responsibility for their learning investment while having at the same time a clear structure, deadlines and contact persons in case of questions. Despite some technical problems, the knowledge acquisition phase had been completed successfully by the participants. In addition, six weeks after the phase where principles and methods were emphasized no loss in knowledge gain could be observed. This might be because participants needed to use the acquired knowledge afterwards in exercises and designing a learning opportunity. The problem solving test revealed that these activities in module 3 and 4 are effective in fostering the ability to apply the previous acquired knowledge.

The overarching goal for a further education course is to influence attitudes and behaviour at the workplace. But ensuring such transfer is difficult. In the case of the postgraduate training program aquwa, the goal was to improve knowledge exchange by qualifying professionals for installing appropriate learning opportunities in their companies. It is a great success that 56% of the interviewed persons reported the realisation of an informal learning opportunity. However, it also shows that it is necessary in further education courses to show and guide participants in applying the gained knowledge.

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Students' Performance Prediction by using Institutional Internal and External Open Data Sources

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Keywords: Academic Performance, Prediction, Decision Tree, External Data Sources, Internal Data Sources.

Abstract: The ability to predict students' mark could be useful in a great number of different ways associated with university-level learning. In this study, student's mark prediction models have been developed using institutional internal databases and external open data sources. The results of empirical study for undergraduate students' first year mark prediction show that prediction models based on institutional internal and external data sources provide better performance with more accurate models compared to the models based on only institutional internal data sources. Moreover, this study explores the external data sources (such as National Student Survey result) as one of the best predictors in students' mark prediction. Also, we found that students' first semester performance is the most informative for their first year performance. We envisage that results such as the ones described in this study may increasingly improve the design of future students' predictive models to support students to perform better in their study.

1 INTRODUCTION

The topic of explanation and prediction of academic performance is widely researched. The ability to predict student performance is very important in educational environments. Increasing student success is a long-term goal in all academic institutions. If educational institutions can predict students' academic performance early before their final examination, then extra effort can be taken to arrange proper support for the lower performing students to improve their studies and help them to success.

Students' academic performance is based upon diverse factors like personal, social, psychological and other environmental variables. Various experiments have been carried out in this area to predict students' academic performance. M.N. Quadri and Kalyankar (2010) showed that students' performance can be predicted using students' gender, students' parental education, financial background and so on. Al-Radaideh et al., (2006) used classification trees to predict the final grade among undergraduate students at Yarmouk University in Jordan. In their study they found high school grade contributed the most in predicting students' final grades. Bharadwaj and Pal (2011) conducted study on the student performance by selecting 300 students from 5 different degree colleges in India. In their study, it was found that students' grade in senior secondary exam, living location, medium of teaching, mother's qualification, family annual income, and student's family status were highly correlated with the student academic performance. Bharadwaj and Pal (2011) in their another study they used students' previous semester marks, class test grade, seminar performance, assignment performance, general proficiency, attendance in class and lab work to predict students' mark in their end semester. Kovacic (2010) used enrollment data to predict successful and unsuccessful student in New Zealand and he found 59.4% and 60.5% of classification accuracy while using decision tree algorithms CHAID and CART respectively. In his study of academic performance prediction, Sajadin Sembiring et al., (2011) found Interest, Study Behaviour, Engage Time and Family Support are significantly correlated with the student academic performance. Yadav and Pal (2012) conducted a study using classification tree to predict student academic performance using students' gender, admission type, previous schools marks, medium of teaching, location of living, accommodation type, father's qualification, mother's qualification, father's occupation, mother's occupation, family annual income and so on. In their study, they achieved around 62.22%, 62.22% and 67.77% overall prediction accuracy using ID3, CART and C4.5 decision tree algorithms respectively. In another study Yavev et al., (2011) used students' attendance, class test grade, seminar and assignment marks, lab works to predict students' performance at the end of the semester with the help of three decision tree algorithms ID3, CART and C4.5. In their study they achieved 52.08%, 56.25% and 45.83% classification accuracy respectively. Vandamme et al., (2007) used decision trees, neural networks and linear discriminant analysis for the early identification of three categories of students: low, medium and high-risk students. Some of the background information such as previous education, number of hours of mathematics, financial independence, and age of the first-year students in Belgian French-speaking universities were significantly related to academic success, while gender, parent's education and occupation, and marital status were not significantly related to the academic success. The Overall correct classification rate they found was 40.63% using decision trees, 51.88% using neural networks and the best result was obtained with discriminant analysis with overall classification accuracy of 57.35%. Cortez and Silva (2008) predicted the secondary student grades of two core classes using past school grades, demographics, social and other school related data. The results were obtained using decision trees, random forests, neural networks and support vector machines. They achieved high level of predictive accuracy when the past grades were included.

The prediction of student performance with high accuracy is beneficial for identify the students with low academic achievements initially. It is required that the teacher can assist the identified students more so that their performance is improved in future. Researchers used various classification methods in their studies to predict students' academic performance, such as decision trees, classification and regression trees, logistic regression, bayesian classification, support vector machine, neural network. Among these decision trees gain popularity in predicting students' performance (Al-Radaideh et al., 2006); (Bharadwaj and Pal., 2011); (Yadav et al., 2011); (Yadev and Pal., 2012). A decision tree is a tree in which each branch node represents a choice between a number of alternatives, and each leaf node represents a decision. Decision tree starts with a root node on which it is for users to take actions. From this node, users split each node recursively according to decision tree learning algorithm (e.g. ID3, C4.5 etc.). The final result is a tree in which each branch represents a possible scenario of decision and its outcome. Among the decision tree algorithms C4.5 gains popularity in terms of its higher performance in classification accuracy (Yadav et al., 2011); (Yadev and Pal., 2012).

This study aims to explore ways to improve the prediction of students marks by evaluating new predictive models based on the combination of internal higher education institution data sources and external datasets in the linked data cloud. The combination of datasets from internal institutional databases and external data sources presents certain challenges such as data are frequently maintained in different locations, in different formats and often with different identifiers. Data aggregation also presents organizational challenges related to the ownership and use of the data (Arnold, 2010).

Linked data technologies are considered to be well suited for data integration. Linked data is interlinked RDF (Resource Description Framework) data that enables users to retrieve quality information from different data sources[1]. In this study, we examine the sufficiency of existing linked data sources to predict students' first year mark.

In section 2, we define the methodology of this study, section 3 provides the experimentation and results of this study, in section 4 we discuss the findings of this study and section 5 provides conclusion.

2 METHODOLOGY

The purpose of this study is to predict students' mark based on institutional internal datasets and data commonly available in the external open data sources. We used the same variables (as many as available in our internal and external datasets) used by Yadav and Pal (2012) in their studies of predicting students' academic performance. In this study, we considered as institutional internal variables, which are commonly available in the institutional internal databases and external variables are those which can be derived or can be used from institutional external open data sources. At the first step, we developed two models (Model1 and Model2) that based a) on only institutional internal variables and b) on institutional internal variables and external open data sources. Subsequently we extended the above two predictive models (Model3 and Model4) adding students' first semester mark to observe the effect of adding current academic performance on the prediction performance of the models. Moreover, this will help us to analyze the effect of external data sources on the both predictive models before and after adding current academic performance (first semester mark).

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[1] http://www.w3.org/DesignIssues/LinkedData.html

Table 1: List of all variables with their description and sources.

Variables name	Description and possible values	Source of the variables
Study_field	Students field of study. Applied (engineering, physics, chemistry etc), Non-applied (Languages etc)	IDS
Gender	Students gender/sex. Male, Female	IDS
Residence	Students Residence/Domicile. UK, Other-EU, Non-EU	IDS
A_level_point	Students result in A level or any other equivalent entry qualifications. A*=140, A=120, B= 100, C=80, D=60 Example, if a student's A level grade is AAA then his A level point counted as AAA=120+120+120=360.	IDS
Adm_Type	Students' admission type. Direct, Clearing	IDS
Accom_Type	Students' accommodation type. University halls, Others	IDS
P_HE	Parents' higher education qualification. Yes, No	IDS
M_Occu_cat	Mother's occupation. Service, House-wife, NA	IDS
F_Occu_cat	Father's occupation. Service, Business, NA	IDS
FirstYr_1stSem_mark	Percentage of mark in first year's first semester. 71%-100%, 61%-70%, 51%-60%, <=50%	IDS
FirstYrMarkrange	Percentage of mark in first year. 71%-100%, 61%-70%, 51%-60%, <=50%	IDS
Part_neighborhood	Students categorized according to their postcode. Lower participation neighborhood, Other neighborhood, NA	EDS (HEFCE)
ONS_soc_eco_class	Students' socio economic class based on parents' occupations. MP-occupations, I-occupations, RM-occupations	EDS (ONS)
P_annual_income	Parents' annual income.	EDS (ONS)
NSS_Q1	Staffs are good at explaining things.	EDS (Unistates)
NSS_Q2	Staffs have made the subject interesting.	EDS (Unistates)
NSS_Q3	Staffs are enthusiastic about what they are teaching.	EDS (Unistates)
NSS_Q4	The course is intellectually stimulating.	EDS (Unistates)
NSS_Q5	The criteria used in marking have been clear in advance.	EDS (Unistates)
NSS_Q6	Assessment arrangements and marking have been fair.	EDS (Unistates)
NSS_Q7	Feedback on my work has been prompt.	EDS (Unistates)
NSS_Q8	I have received detailed comments on my work.	EDS (Unistates)
NSS_Q9	Feedback on my work has helped me clarify things I did not understand.	EDS (Unistates)
NSS_Q10	I have received sufficient advice and support with my studies.	EDS (Unistates)
NSS_Q11	I have been able to contact staff when I needed to.	EDS (Unistates)
NSS_Q12	Good advice was available when I needed to make study choices.	EDS (Unistates)
NSS_Q19	The course has helped me present myself with confidence.	EDS (Unistates)
NSS_Q20	My communication skills have improved.	EDS (Unistates)
NSS_Q21	As a result of the course, I feel confident in tackling unfamiliar problems.	EDS (Unistates)
NSS_Q22	Overall, I am satisfied with the quality of the course.	EDS (Unistates)

In this study we used WEKA for data analysis. The Weka Knowledge Explorer is an easy to use graphical user interface that harnesses the power of the Weka software (Holmes et al., 1994). It is an open source software that implements a large collection of machine learning algorithm and is widely used in data mining application (Al-Radaideh et al., 2006); (Yadav et al., 2011); (Yadev and Pal., 2012). In this experimentation we used decision tree classification technique to build the models. The classification tree models have some advantages over traditional statistical models such as logistic regression and discriminant analysis traditionally used in retention studies. First, they can handle a large number of predictor variables, far more than the logistic regression and discriminant analysis would allow. Secondly, the classification tree models are non-parametric and can capture nonlinear relationships and complex interactions between predictors and dependent variable. We used J48 decision tree algorithm to develop the mark prediction model. J48 algorithm is the Weka implementation of the C4.5 top-down decision tree learner proposed by Quinlan (1993). The 10-fold cross validation method was used to validate/evaluate the model in WEKA.

2.1 Data and Data Sources

In this study we considered two types of variables, a) variables from institutional internal data sources (IDS) and b) variables from institutional external (open) data sources (EDS).

In this study we motivate to use NSS result published in Unistates website as an external data source to predict students' first year mark. Every year the NSS conducted to measure students' satisfaction in different dimensions of their study subjects in their institutions such as satisfaction in teaching and learning, assessment and feedback, academic support, organization and management, learning resources and personal development. Unistats does not publish individual student data. NSS measures students' satisfaction on their program of study in a 5 points scale (Definitely Disagree, Moderately Disagree, Neither Agree nor Disagree, Moderately Agree, Definitely Agree). The website publishes the percentages of respondents in each scale for an individual course. We considered the actual value (for % Agree) for all the questions for 2010-2011 academic year's published result for the university of Southampton to include in our study to develop the predictive model. Also, Office for National Statistics (ONS[2]) published data has been used in this study to derive parents' annual income (based on ONS published gross annual salary based on SOC2010) and students' socio economic class (based on Standard Occupational Classification 2010). Moreover, we derived participations neighborhood group using Higher Education Funding Council for England (HEFCE[3]) published dataset as some studies found students' participation neighborhood has an impact on students' outcome. Therefore, we considered to include this variable in our prediction model. Table 1 provides the list of all the variables used in this study with their sources.

2.2 Experimentation

The objective of this study is to

a) examine the capability of institutional external open data sources to predict students' mark while combining with only students' enrollment data, and

b) examine the capability of the institutional external data sources while combing with students' enrolment data and current academic performance (students' first semester mark).

Therefore, for the above objectives an analysis of the importance of the variables of the predictive model was necessary. Therefore, we use "select attribute" option from WEKA explorer to select the significant variables/attributes. Considering the variables/attributes with score value greater than "0", we developed four predictive models (Model1, Model2, Model3 and Model4) as described in the methodology. The total number of participants in our study is 149 of which 60.4% is male and 39.4% is female.

3 RESULT AND DISCUSSION

For the first model (model1) we considered 9 input variables/attributes and found all of them are significant and scored greater than "0" for the prediction of first year mark. Table 2 provided the list of these ranked attributes according to their relative importance with their score value. The highest scored attributes are more significant compared to other attributes. From table 2 it is found that students' mark prediction is highly dependent on student' A level point and then mother occupation, field of study, admission type, father occupation and so on. For model2 we considered total 28 internal and external variables of which only 15 variables/attributes are found to be significant and scored greater than "0". Table 3 presents the list of these 15 attributes with their score value. From table 3 it is found that students' mark prediction highly dependent on A level point and NSS five questionnaires (Q2, Q6, Q9, Q5 and Q8). Among other variables mother occupation, study field, admission type, father occupation, socio economic

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[2] http://www.ons.gov.uk/ons/index.html

[3] http://www.hefce.ac.uk/

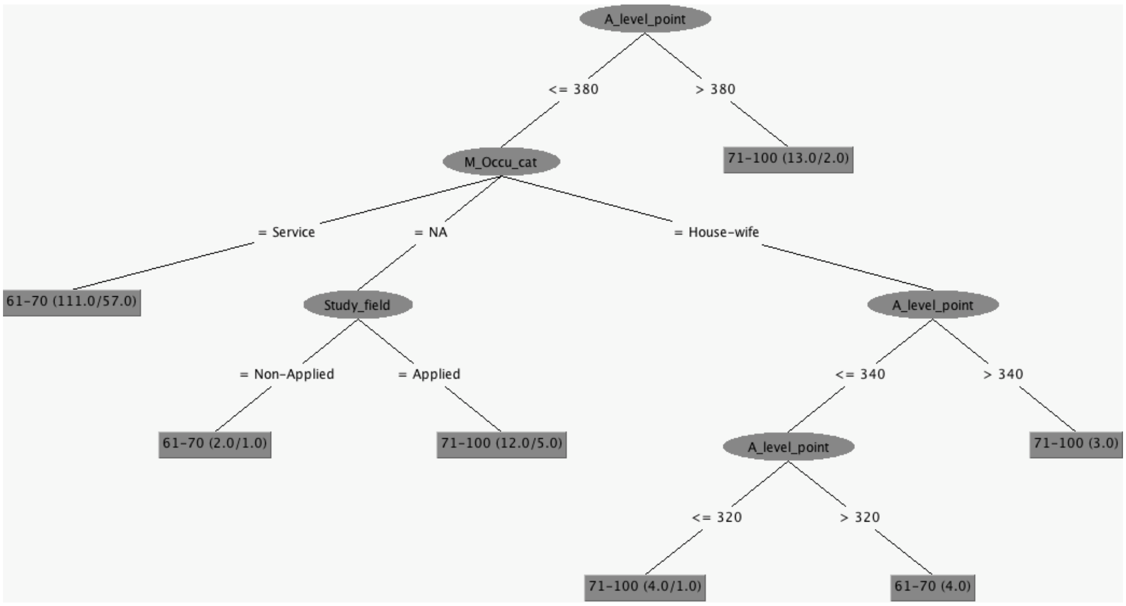

Figure 1: J48 rule for model1.

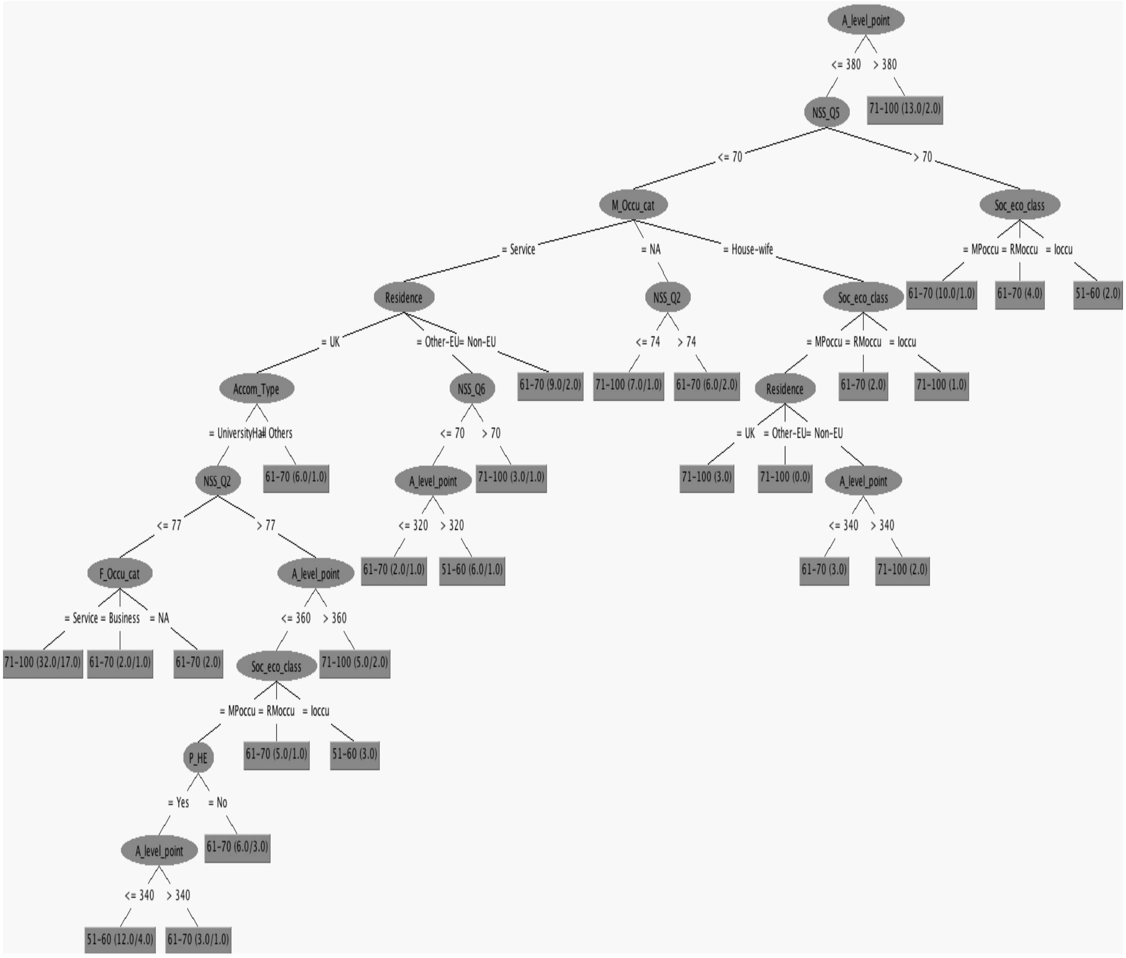

Figure 2: J48 rule for model2.

status and so on. For model3 10 out of 10 input variables/attributes are found score value is greater than "0" and considered to build the classification model. Table 4 provides the variables/attributes list with their score values and table 5 provides the list of considered variables for model 4. There are 17 out of 29 internal and external variables/attributes are found to be score value greater than "0" and hence considered for the model development. From table 4 it is found that students' mark prediction is highly dependent on students' first semester mark and then A level point, NSS five questionnaire (Q2, Q6, Q8, Q5, and Q9) and so on. Figure 1, 2, 3 and 4 presents the classification rule generated by J48 decision tree algorithm for model1, model2, model3 and model4 respectively.

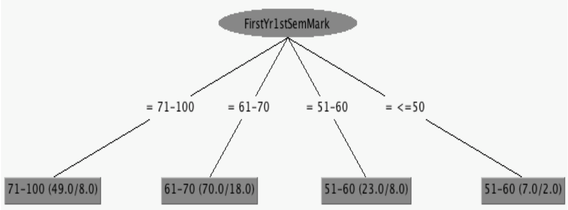

Figure 3: J48 rule for model3.

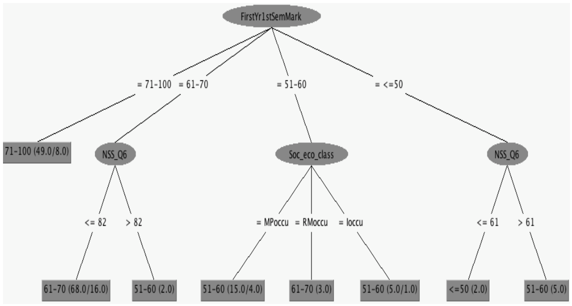

Figure 4: J48 rule for model4.

Table 2: Selected variables/attributes with their score for model1.

Variables/Attributes name	Score
A_level_point	0.455
M_Occu_cat	0.262
StudyField	0.253
Addm_Type	0.225
F_Occu_cat	0.218
Residence	0.184
Gender	0.17
P_HE	0.126
Accom_Type	0.119

The summary of the classification on the datasets using 10-fold cross validation for model1 and model2 presents in table 6; and table 7 presents the accuracy of the classification for model3 and model4. Table 6 shows that model based on institutional internal and external open data sources (model2) performs better in predicting students mark compared to the model using only institutional internal datasets (model1). Compared to the model using only institutional internal databases, model using external data sources achieved around 5.37% more accuracy in the classification. Including students' current academic performance (first semester mark) in the both predictive models (model1 and model2), we get overall accuracy 74.50% for model based on only institutional internal datasets (model3) and 76.51% overall accuracy for model using institutional internal datasets and commonly available external open data sources (model4). It is found that adding students' first semester mark in both models (model1 and model2) the prediction performance increased remarkably from 46.98% to 74.50% and 52.35% to 76.51%. Besides, it is noted that model based on institutional internal and external open data sources performs better among them. Additionally, it can be strongly said that students' first year mark highly dependent on students' current academic performance (first semester mark).

Table 3: Selected variables/attributes with their score for model2.

Variables/Attributes name	Score
A_level_point	0.455
NSS_Q2	0.335
NSS_Q6	0.335
NSS_Q9	0.325
NSS_Q5	0.325
NSS_Q8	0.325
M_Occu_cat	0.262
Study_field	0.253
Addm_Type	0.225
F_Occu_cat	0.218
ONS_soc_eco_gp	0.21
Residence	0.184
Gender	0.17
P_HE	0.126
Accom_Type	0.119

From table 7 it can also be said that using external data sources in the model improved around 2.01% accuracy of the model compared to the model based on only institutional internal datasets. Table 6 and 7 also presents class wise TP (True positive) rate, FP (False positive) rate, precision and recall value for each model. Our study results also support Kember's study (1995), where the author stated that background characteristics are not good predictors of final outcomes because they are just a starting point. Our study results also strongly support (Kovacic and Green, 2010), where the authors strongly suggested that the previous academic result plays a major role in predicting students' current academic performance. Also from this study it is evidenced that including external data sources can improve prediction performance. In this study, national student survey (NSS) result contributes significantly in predicting students' mark where five NSS questionnaires (Q2, Q6, Q8, Q5 and Q9) conquered 3rd to 7th significance position while selecting significant variables for the model.

Table 4: Selected variables/attributes with their score for model 3.

Variables/Attributes name	Score
FirstYr-1stSem_markrange	0.781
A_level_point	0.455
M_Occu_cat	0.262
Study_field	0.253
Addm_Type	0.225
F_Occu_cat	0.218
Residence	0.184
Gender	0.17
P_HE	0.126
Accom_Type	0.119

Table 5: Selected variables/attributes with their score for model 4.

Variables/Attributes name	Score
FirstYr-1stSem_markrange	0.781
A_level_point	0.455
NSS_Q2	0.335
NSS_Q6	0.335
NSS_Q8	0.325
NSS_Q5	0.325
NSS_Q9	0.325
M_Occu_cat	0.262
StudyField	0.253
Addm_Type	0.225
F_Occu_cat	0.218
ONS_soc_eco_gp	0.21
Part_neighborhood	0.186
Residence	0.184
Gender	0.17
P_HE	0.126
Accom_Type	0.119

Table 6: Summary of the classification model1 and model2.

Model Name	Class	TP Rate	FP Rate	Precision	Recall	Overall accuracy (%)
Model 1	71-100	0.417	0.188	0.513	0.417	46.98
	61-70	0.769	0.69	0.463	0.769	
	51-60	0	0.017	0	0	
	41-50	0	0	0	0	
Model 2	71-100	0.563	0.238	0.529	0.563	52.35
	61-70	0.662	0.393	0.566	0.662	
	51-60	0.276	0.092	0.421	0.276	
	41-50	0	0.021	0	0	

- Model1: based on **only institutional internal database**.
- Model2: based on **institutional internal database and available external data sources**.

Table 7: Summary of the classification model3 and model4.

Model Name	Class	TP Rate	FP Rate	Precision	Recall	Overall accuracy (%)
Model 3	71-100	0.854	0.079	0.837	0.854	74.50
	61-70	0.8	0.214	0.743	0.8	
	51-60	0.621	0.083	0.643	0.621	
	41-50	0	0.014	0	0	
Model 4	71-100	0.854	0.079	0.837	0.854	76.51
	61-70	0.815	0.214	0.746	0.815	
	51-60	.69	0.075	0.69	0.69	
	41-50	0	0	0	0	

- Model3: based on **only institutional internal variables** plus **first semester mark**.
- Model4: based on **institutional internal database and available external data sources** plus **first semester mark**.

4 CONCLUSIONS

This study will help to the students and the teachers to improve the performance of the students. This study introduces students mark prediction model development approaches based on institutional internal and external open data sources that can be used in practical settings to predict students' academic performance. The result of this study shows that model based on institutional internal databases and external open data sources performs better than the model based on only institutional internal databases. Furthermore, the result strongly supports that students' current academic performance is the best predictor in predicting students' mark. Among other predictors A level point, NSS results are also highly recommended. This study underlines the importance of linked open data sources in developing predictive models. Therefore, this study suggests more research study using external data sources in this area.

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User Interaction-framework for Adaptive ERP Education

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Keywords: Web-based Information Systems, ERP Systems, Intelligent Tutoring Systems, ERP Education, GRAPPLE.

Abstract: Current methods used to learn and understand information systems in a company or in the field of higher education are not sufficient when it is compared to the capabilities of today's technologies. The most common method used to teach and learn the practical issues of an information system is with the help of case studies. However, the learning material in a case study provided to the learner is neither technologically-enhanced nor adapted to the individual knowledge background and learning preferences of a single, individual learner in a group. Adaptive learning environments offer a sufficient way to teach and learn the usage of an information system while it tracks user interactions and adapts the learning content towards the learner's performance. Thus, the lacking integration of an adaptive learning environment with the target information system is a major issue. In this contribution, we are presenting a developed user interaction-framework (UIF) for web-based information systems (WBIS) in order to generate individual tasks for each single learner depending on his specific performance during a hands-on learning process.

1 INTRODUCTION

The complexity of enterprise systems or information systems (IS) in general, as an important part of today's companies, increases more and more. The pervasion of computer supported business processes in today's enterprises affects nearly all business sections and their employees (Konradin, 2011). This is especially the case for Enterprise Resource Planning (ERP) systems, which integrate data, processes and functions of different business departments, such as financial accounting, production or sales and distribution (Gronau, 2010).

At the same time, the resulting, raising need of appropriate learning material and employee trainings needs to be met. In companies, as well as in tertiary education institutes, like universities e.g., it is highly relevant to bring people in contact with these systems in order to ensure an effective use of the different systems (Konstantinidis et al., 2010). Primarily business economics or business informatics people need to be educated in this area, but also engineers or computer scientists should be addressed. Especially the practical use of these systems is an important part of getting people familiarized with the software. Therefore, this hands-on experience needs to be addressed by future learning methods. This trend is also discussed in the literature very well (cf. Hawking et al., 2005; Strong et al., 2006; Cameron, 2008; Winkelmann et al., 2012).

Unfortunately, the existing training methods don't fulfil this higher and specific demand. The current and most common way to learn the practical issues of a system is to conduct case studies. But these case studies lack due to different reasons. First of all, the common case studies do often not have a deeper didactical background. This is because they are mostly created by the software vendors themselves and therefore only include technical or functional issues. Furthermore, existing case studies are paper-based and not technology-enhanced in general. Therefore, the learner cannot benefit from well-known advantages coming from methods like distance learning or community-based approaches. The reuse of learning material is much easier within electronic learning environments (Baumgartner and Kalz, 2005). This is very important, because the systems are changing a lot due to software updates and new software releases. The biggest shortcoming is the ignorance of specific characteristics of each individual learner. Most of the time, the learners have a different background in knowledge and skills, but existing learning material often addresses a group of people or students, which are very heterogeneous in their style of learning. Some learners are working on a case study very active and reach the learning target very quick. Some others need more theoretical information about the specific functions in order to complete a task with satisfaction.

2 ADAPTIVE INFORMATION SYSTEM-EDUCATION

According to the literature, intelligent learning systems exist since the beginning of the 1980s (Schulmeister, 2007). Surely, the term *intelligent* has a very vague definition, but starting with the first computer assisted instructional programs, the first *reactive* or *adaptive* systems were developed in that decade. The combination of computer technology with methods from the artificial intelligence (AI) aiming at the improvement of educational instructions can be summarized under the most important software category, called Intelligent Tutoring Systems (ITS) (Gharehchopogh and Khalifelu, 2011). In a general understanding, ITS consist of a model of the knowledge of a specific domain (domain model), a model of the learner who uses the learning system (learner model), a model of the pedagogical strategy (tutor model) and a component which is responsible for the communication of the system with the learner (interface) (Schulmeister, 2007). Therefore, ITS can also be classified as adaptive learning systems, because they react on the basis of the learner behaviour (Brusilovsky, 2001). Reference models of adaptive learning environments such as GRAPPLE, which is used as the basis of the developed UIF, are implementing the basic concepts in order to create a broader environment for the learner and her/his educational life.

The domain of IS is very relevant for a large group of learners in the field of higher education institutes (Peters et al., 2012). Furthermore, the IS education lacks in efficiency due to the described reasons. At the moment, there are no adaptive learning environments existing which focus on this specific IS domain and target group. Therefore it is highly relevant to make use of the named major advantages.

3 OBJECTIVE AND APPROACH

In general, the primary objective of our research was to develop a framework which allows the integration between an adaptive learning environment and a real environment of a WBIS.

In order to achieve this objective we developed a technical solution in a form of a learning system which firstly supports the tracking of user interactions and secondly offers the possibility to display additional information, such as learning instructions or tasks, within that environment. This all should be done without modifying the source code of the target web-based information system. In the research process, existing related systems and approaches were reviewed to identify ways of user interaction tracking and ways to display additional information. After this literature review, we found out, that the proposed UIF can be based on an existing reference model called GRAPPLE which already comes along with some major functionality for an adaptive learning environment, like the design of an adaptation engine or the definition of adaptation rules. Based on that reference model, the theoretical concept of the UIF was designed. In a last step, a UIF prototype was developed in order to proof the underlying concept. The results are presented and discussed in the following section.

4 USER INTERACTION-FRAMEWORK

Nowadays, learning environments have no direct connection between the learning system and the IS itself. As a result, students work with two isolated systems. But both systems contain relevant data which can be used to improve the learning process. By integrating both systems, the learning environment can benefit from the existing data stored in the IS.

According to Figure 1, the design introduces existing components of a learning environment, namely the students, the WBIS, the learning system (LS) and the teacher. In order to overcome the lack of integration the UIF adds three more components to the information flow, namely the configuration file, a browser plug-in and the tracking and displaying script, to directly connect the LS with the WBIS. This allows a way of learning where students are able to receive their learning tasks, additional information and guidance as well as support directly within the targeted WBIS.

From the user interaction point of view, the student operates with the WBIS regularly via web browser which has the UIF-browser-plugin installed. This plugin receives information and tasks from the LS over a displaying script and displays the tasks at the right place directly on top of the WBIS. In addition, the plugin communicates with the LS over the tracking script. This tracking script forwards the student interactions directly through the LS. This enables the LS to instantly evaluate the learning results and students' behaviour in order to adapt the learning process in terms of giving the student a new task or additional help information.

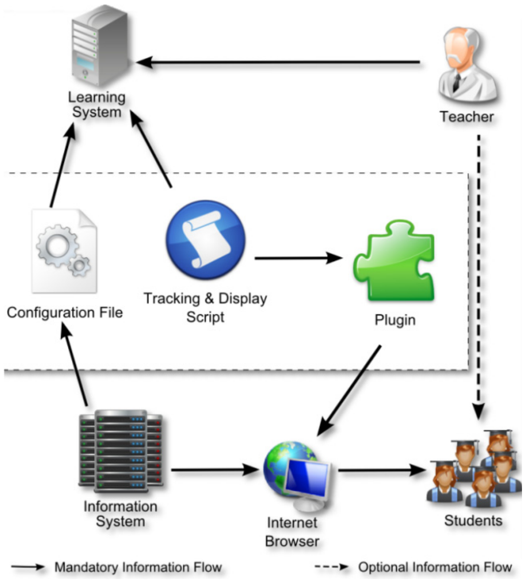


Figure 1: Information Flow.

In order to make use of the UIF the creation of a configuration-file is necessary as an initial step. This file includes the structure of all relevant html-elements of the GUI of the WBIS. This creation needs to be done once for all relevant GUI-elements, which want to be used in the context of a learning scenario. Through this configuration-file the LS *knows* about the structure of the WBIS and is able to allocate html-elements to a function of the WBIS.

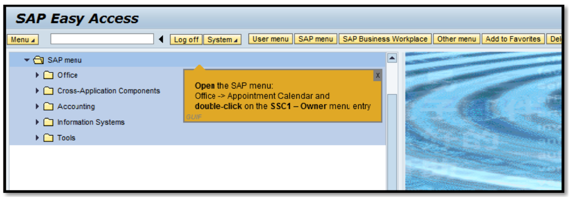
The underlying (adaptation) logic is delivered by the GALE (Adaptivity GRAPPLE Adaptive Learning Environment) framework as part of the mentioned GRAPPLE framework. There, it is possible to define adaptation rules, which describe the exact behaviour of the LS. More precisely, the adaption rules deliver a reasoning which exercise will be presented to the student based on the tracked information of the students' performance. As an example, the system can provide positive feedback, if the learner clicks on the correct button within the WBIS according to her/his current task. However, if the user clicks on a wrong button, she/he might get additional information about what was wrong and how the problem can be solved in a next step. Besides these very simple examples, the UIF also allows the definition of more complex adaptation rules in order to provide a more efficient learning experience.

5 UIF PROTOTYPE

This section demonstrates the use of the proof-of-concept prototype within a use case scenario. The chosen WBIS for the prototypical implementation is SAP NetWeaver Portal installed in version 7.02 ABAP Trial Version on a virtual appliance of a Windows Server 2003 R2.

The learning task of the use case scenario is to show the learner how to create a new appointment in the personal calendar of the WBIS in the SAP Easy Access menu. Therefore the UIF will guide the learner through two different ways of doing this (a way represents a certain domain model). The first approach is designed for novice users, showing them how to perform the tasks by using a common navigation path. The second approach is designed to be executed by advanced users and shows how to perform the tasks using a navigation shortcut.

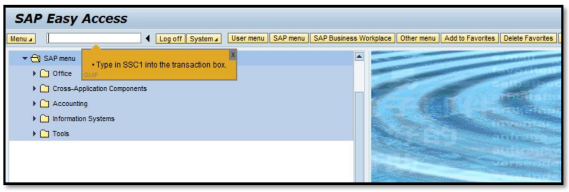
After the login, the learner is located on the SAP Easy Access page. The first domain model is activated and shows the first task. Figure 2 exemplifies how this information is displayed in the learning environment. The UIF tracks when the learner has performed this task and the UIF will display further information on the next pages. After the user has entered some information into the form the UIF shows the next task. In order get an overview about the main idea of the use case scenario, not every single screen of the described use case scenario is shown here. Finally, the user is led back to the SAP Easy Access page.



Open the SAP menu:
Office -> Appointment Calendar and
double-click on the **SSC1 – Owner** menu entry

Figure 2: UIF SAP Example 1.

After completing the first task, the second domain model is activated, because the first domain model is marked as known to the learner. As shown in Figure 3, on the SAP Easy Access page the UIF instructs the learner in a different way. After this interaction has been tracked the next advice will be given by the UIF and so on.



• Type in SSC1 into the transaction box.

Figure 3: UIF SAP Example 2.

During this example learning session the UIF has shown seven instructions (four in the first and three in the second domain model) and tracked ten interactions (six in the first and four in the second domain model). Finally, the learner has created two appointments in her/his personal calendar in two different ways and mastered two domain models.

6 CONCLUSIONS AND OUTLOOK

In this contribution we presented a UIF which allows the allocation of individual learning tasks to different learners who want to get familiar with the usage of WBIS. Therefore, we presented an integrated approach in order to track the learner's behaviour and display upcoming learning tasks within the information system itself. Based on the learner interaction, the UIF offers the possibility, to allocate different kinds of tasks with regards to previous knowledge and/or learning style, to different types of learners.

The main idea of this contribution is the integration of an adaptive learning environment with a real, existing IS. This system and data integration generates the main benefit of our approach which is mainly the possibility of tracking, collecting and analysing data about the learner's tasks and her/his performance in the system. Furthermore, through this integration, tasks can be displayed context-sensitive on top of the GUI of the WBIS. In summary, we provide an approach which gives the opportunity to learners to gather from hands-on experience in a more efficient way of learning in the field of IS education.

For future work, the prototypical implementation can be enhanced with further functions and use case scenarios in order to conduct a field study together with students. Based on these experimental results, it is possible to enhance the presented qualitative added values of our approach with facts about the quantitative improvements in IS education.

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Storyboarding Serious Games for Large-scale Training Applications

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Keywords: Game Based Learning, Game based Training, Storyboarding, Staff Training, Disaster Management.

Abstract: Beyond the limits of conventional media such as motion picture and theater dominating the passed centuries, storyboarding means the design of interaction to meet anticipated affective and effective human experience. Storyboarding plays a key role in research and applications in areas such as interactive digital storytelling, but in e-learning, in general, and in game based learning, in particular, there shows an enormous deficiency. There is abundant evidence for the need of establishing storyboarding in the design of game based learning. Large-scale training applications reaching thousands of trainees in operation are particularly demanding. A certain game developed and implemented for training of staff in disaster management demonstrates the inevitability of storyboarding as a key technology of design supporting adaptive system behavior, in particular. Storyboards are digital objects within a systematic design and development process. Storyboarding supports the completeness and correctness of the design. Visual features of a storyboard allow for checking different balances such as the one between learning about a human learner and adapting to the learner's individual needs, desires, and preferences. Furthermore, storyboards allow for an intuitive editing of the interaction scenario.

1 THE AUTHORS' POSITION

Digital games to be deployed for realistic large-scale learning and training applications are highly complex digital systems. The manifold of possible interaction sequences is enormous; the storyboard in use throughout this paper, just for illustration, contains 13 006 893 219 840 paths from the start node to one of the end nodes.

Games purposefully designed and implemented challenge the human imagination of forthcoming sequences of human-system interactions and their potential points of branching or confluence. Storyboards are tools to represent anticipated experiences (Jantke and Knauf, 2005).

Consequently, one should imagine storyboarding investigations to play a certain role in educational research and reflections thereon. Far from it, just for illustration, the whole proceedings of the last CSEDU conference contain only a single paper dealing with storyboarding (Jantke and Knauf, 2012) and one more paper using the term (Colasante and Lang, 2012).

In response, the authors present this submission to advocate storyboarding by means of a large-scale training application currently used by the German agency for civil protection and disaster management.

2 TRAINING OF PREPAREDNESS FOR DISASTER MANAGEMENT

The German Federal Agency for Civil Protection and Disaster Management (German acronym: BBK)–an Agency of the Federal Ministry of the Interior–in its academy located near Ahrweiler is providing training to more than 1,000 people of staff per year to be well-prepared for any type of natural or technical disaster.

The present authors provide software modules for game based training to the BBK's academy.

It is difficult to predict, especially the future, is a saying ascribed to the Danish physicist Niels Bohr. This applies to forthcoming disasters, in particular.

Staff members of crisis management groups can not be confronted to all possibly forthcoming details. In addition to some large amount of knowledge and to the acquisition of behavioral skills and patterns, staff needs to familiarize with acting in the conditions of a crisis. Repeated game play in varying situations is an appropriate methodology of developing preparedness.

The aim of this paper is to advocate the authors' position that storyboarding is a valuable technology of serious games design and implementation and to convince the readers by means of a certain practically relevant serious game for real training operations.

3 STORYBOARDING FOR PURPOSES OF EDUCATION

This paper uses storyboarding as a technology, but does not aim at anything such as an introductory course to storyboarding. The authors rely on the ideas introduced by (Jantke and Knauf, 2005) and confine themselves to those notions and notations needed for storyboarding game-based learning. Recent work on storyboarduing digital games such as (Jantke and Knauf, 2012), e.g., is worth some comparison.

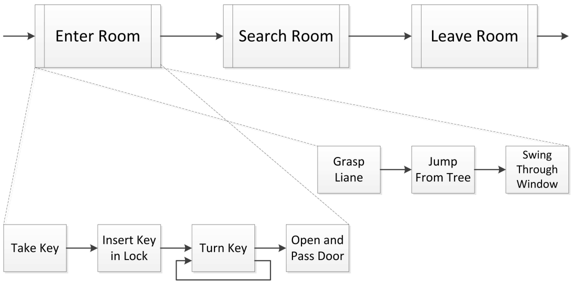


Figure 1: Cutout of some storyboard of a digital game showing two alternative graph substitutions for one episode.

Storyboards are hierarchically structured graphs. The composite nodes are named episodes, whereas the atomic nodes are named scenes. Composite nodes may be subject to substitution by other graphs. Atomic nodes, in contrast, have some semantics in the underlying domain. They may represent documents such as videos, pictures, or text files in any format, but they may also represent some activities of human learners, teacher, tutors, or those actions performed by certain digital systems. The usage of composite nodes in a graph allows for the representation of anticipated experiences on different levels of detail.

Just for illustration, fig. 1 above is showing two alternative substitutions for an episode. The graphs for substitution on display contain only scenes which have a particular operational semantics. In general, subgraphs may also contain episodes.

Graphs may contain branches and loops, where there are different branches for indicating alternatives, multiple choices, parallelism of action, and the like.

Every storyboard specifies a usually rather large number of paths through the storyboard describing, for instance, varying experiences of game playing or different ways of learning.

The art of storyboarding is to anticipate and to specify in detail the manifold of forthcoming actions including human-computer interaction. It takes into account off-line activities as well as human-human communication and physical interaction.

4 STORYBOARDING FOR EDUCATIONAL ADAPTIVITY

There is no need at all to advocate adaptivity on a conference of computer supported education, because every good teacher is used to adapt to the needs of his students. There are excellent publications in the field such as (Brusilovsky, 1996), (Brusilovsky, 2001), and (Brusilovsky and Maybury, 2003).

Adaptivity came first up in natural language processing research (Perrault et al., 1978) and found some consolidation in the middle of the nienties of the last century (Oppermann, 1965).

Nowadays, adaptivity is widespread and opinions vary largely. Many authors prefer a low expectations approach seeing adaptive hypermedia systems as anything *which reflects some features of the user in the user model and apply this model to adapt various visible aspects of the system to the user*, as expressed by (Henze and Nejdl, 2004), for instance.

Largely independent and unrelated research work in educational and developmental psychology, in particular, and cognitive science, in general, suggests deeper modeling approaches like, e.g., *Conceptual Change Theory* (see (Carey, 1985), (Carey, 2000), and (Thagard, 2012)).

Taking such background research of adaptivity into account, apparently user modeling may be seen as theory induction (Jantke, 2013). A system being adaptive is inductively building some theory about its current user's needs and desires. The digital system's behavior, at every moment in time, is based on the recent state of the hypothesized theory.

This view does perfectly apply to all the well-established learner models, user model, and player models currently in use.

For demonstrating *storyboarding serious games* in use in *large-scale training applications*, the authors have chosen the learner model of (Felder and Silverman, 1988) which meets the requirements of learning to act in the focused application domain.

After the two short introductory sections on the present page of the position paper, the following pages will contain detailed material of the authors' application project.

When certain user profiles are on display, they represent Felder-Silvermann-based theories on some current learner. The storyboards report the authors' design process in which human playing and learning experiences are anticipated.

The storyboards are represented in XML (more precisely: RDF) such that the running system works by interpreting the specified interaction opportunities.

5 PRACTICAL STORYBOARDING OF STAFF TRAINING TOWARD DISASTER MANAGEMENT PREPAREDNESS

This section is demonstrating the authors' position by means of a report about some relevant application.

The TRAST system developed for the German Federal Agency for Civil Protection and Disaster Management has been implemented in UNITY as a 3D game module. For major roles in a crisis management staff, storyboards like the one on display in fig. 2 have been developed. It is not intended to read any of the inscriptions in the storyboard graph below, but to get an impression of some storyboard as a whole.

The rectangular nodes represent particular scenes in the game story. A node includes some actions activated by the system when the game state is reaching the node. Actions may be any atomic system behaviors such as showing a text message dialog, showing some pictures, or setting up an interaction button on

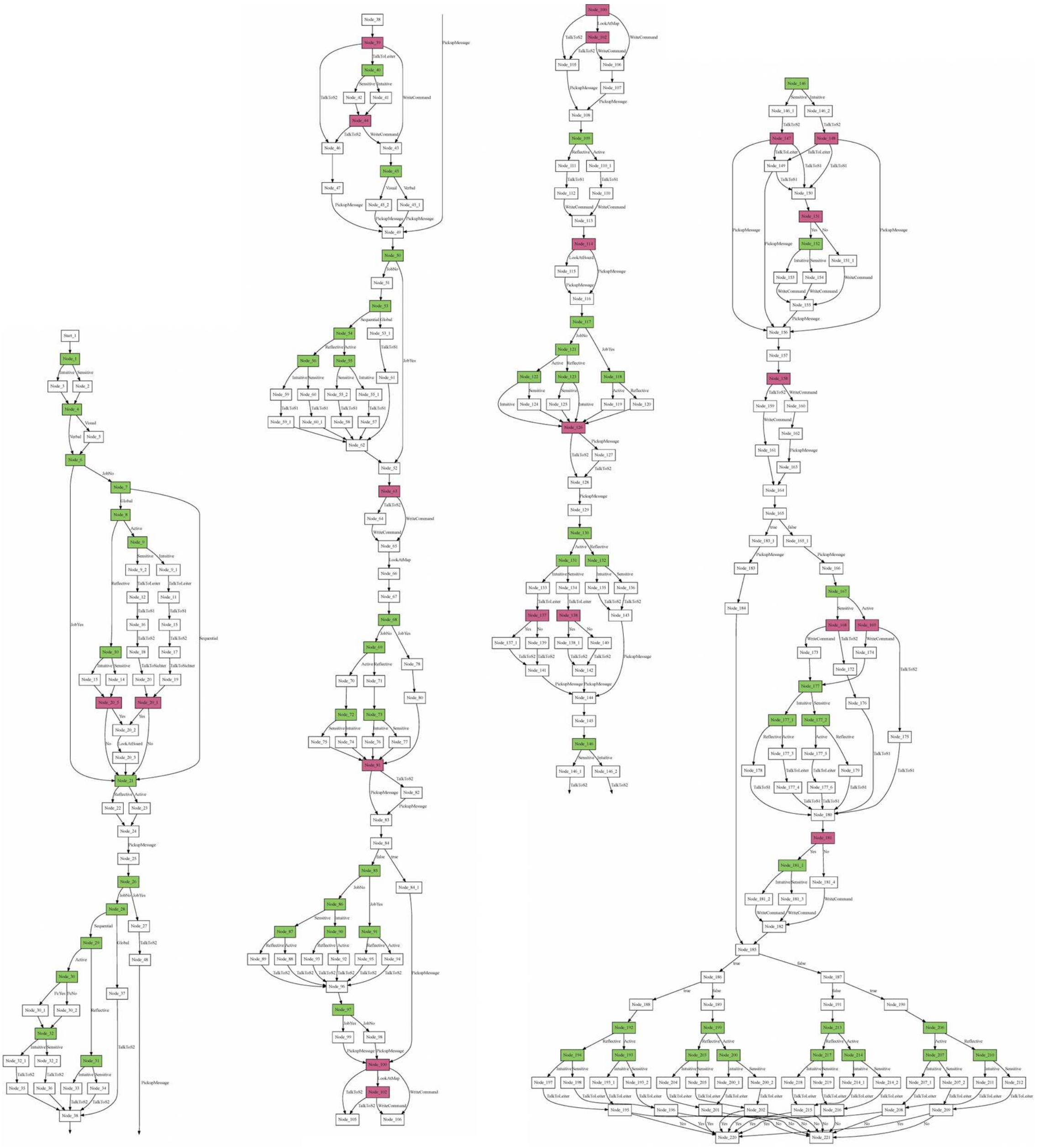


Figure 2: Storyboard of one of the seven staff positions in the training system TRAST; storyboard cut into four pieces.

an object in the game. Nodes are connected with transitions (represented as arrows in the figs. 2 and 3). Some transitions have labels which indicate names of events fired by the system according to users' choice in the game play or their profiles. When the system detects an event in a specific node, the system selects the transition which is labeled with the corresponding event name and takes the transition to proceed.

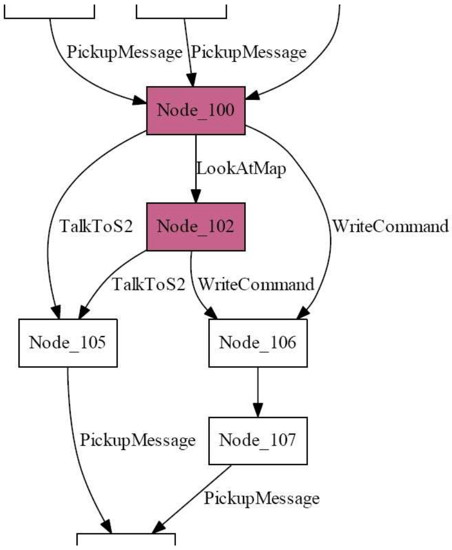


Figure 3: Cutout of the TRAST storyboard at node 100.

Figure 4: Moment of the learner's choices when playing.

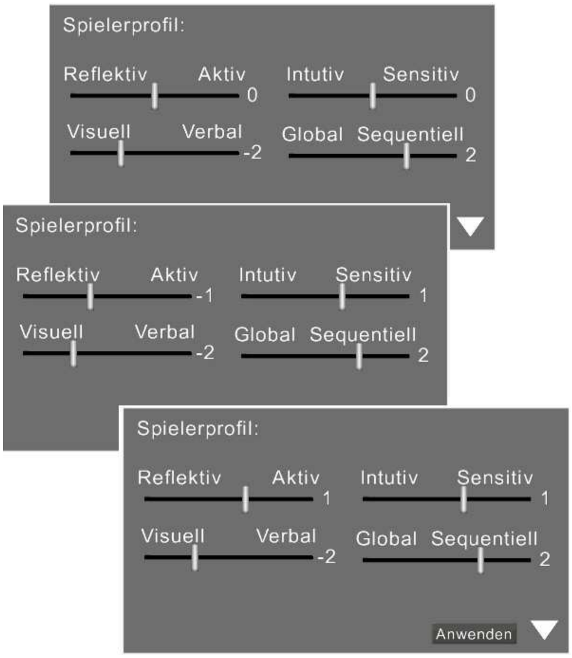
Due to the restricted space within this position paper, the authors confine themselves to an illustration of the storyboard's relevance for implementing the key feature of adaptivity.

At all nodes colored in red, the players have choices which are interpreted by the digital system and reflected in the user profile. The nodes colored in green include different system behaviors according to the user profile.

The scenery on display in fig. 4 shows the system's interpretation of the storyboard cutout in fig. 3. In scene 100, the learner has three different choices to act indicated by orange buttons (from left to right): Writing a message, talking to the staff member next to the map, inspecting the map.

The player's choices are interpreted as preferences and used for another step of user profile induction.

The following picture illustrates different changes of some user profile in dependence on the observed player's behavior.



Spielerprofil:
Reflektiv Aktiv 0
Intutiv Sensitiv 0
Visuell Verbal -2
Global Sequentiell 2

Spielerprofil:
Reflektiv Aktiv -1
Intutiv Sensitiv 1
Visuell Verbal -2
Global Sequentiell 2

Spielerprofil:
Reflektiv Aktiv 1
Intutiv Sensitiv 1
Visuell Verbal -2
Global Sequentiell 2

Figure 5: FELDER/SILVERMAN Theory Induction.

Assume the player did arrive at the scene denoted by node 100 having a profile in the background which is shown by the topmost configuration on display in fig. 5. When players prefer to write a message, profiles change to the one displayed in the middle. When talking to the staff member at the map instead, the profiles change to the one displayed at the bottom of fig. 5 because an "active" person tends to prefer conversation with others.

According to the user profile, the system behaves differently in the green nodes. For example, for a player modeled as a "visual" person, as it is assumed that such a person prefers visual representation to text-based representation, the system shows more pictures or videos for giving information to the player.

The visual appearance of storyboards supports didactic design as well as goal-oriented adaptivity. The location and distribution of branching points, where theory induction is triggered, may easily be controlled as well as the location and distribution of points where the system behaves adaptively. By means of direct modifications in the storyboard, alternatives may be easily checked.

Storyboards form a suitable basis for interdisciplinary discourse, because domain specialists, educational specialists, and system developers may take the same document as a basis for inspection, for asking question, for making proposals, and the like.

Note that the RDF storyboard is not only a specification of forthcoming playful interactions, but at the same time an implementation of the system's part in the interaction. This system is reading in the storyboard and acting accordingly. This bears potentials for further extensions of adaptive behavior in practice.

6 CONCLUSIONS

The project TRAST reported in the present paper is a proper application case of game based learning in use for quite serious purposes of learning and training.

When projects of computer supported education are under development, a large number of aspects have to taken into account and a wide spectrum of needs and desires have to be satisfied. There arises abundant evidence for the need of planning.

Storyboarding is the methodology advocated to plan the rich manifold of potential human learners' experiences.

In particular, the authors advocate throughout the present paper the position that the developed storyboards are not only design documents, but may serve as components of the digital system anticipated.

If this is the case, the crucial problem of transforming storyboards into some semantically correct implementation disappears. The digital game system is reading the storyboard and is interpreting the flow of control and data specified by means of the graph structure. Digital storyboarding is advantageous.

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UBIQUITOUS LEARNING

FULL PAPER

Designing Virtual Laboratories

Decarboxylation Reactions, Vacuum Distillation and Virus Identification by PCR in the Lablife3D Second Life Laboratory

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Abstract: Practical skills are one of the core competencies in technology, engineering and the natural sciences. However, the busy curriculum in many universities lacks space and time for the learning-by-doing experience to mature. Therefore, we have designed and implemented a virtual laboratory, LabLife3D, to Second Life, to bridge the gap between theory and practice. To date, we have designed five virtual laboratory exercises in the biological sciences and chemistry there: a virus isolation experiment, a laboratory safety tutorial, organic chemistry simulations on (a) decarboxylation reactions and (b) vacuum distillation, and a molecular biology simulation on identifying a virus with polymerase chain reaction (PCR). This paper presents their design process and outlines their contents. General design objectives in virtual laboratories are also discussed, along with laboratory simulations in Second Life by other groups. All the exercises have been designed in accordance with content-specific learning goals and outcomes, which are discussed. In addition to creation of contents, we have also recently studied the usability of our simulations and conducted a student assessment. Preliminary results of the student assessment are presented.

1 MOTIVATION

Three-dimensional (3D) virtual worlds represent recent developments in information technology and they will undoubtedly become significant learning spaces for future student generations, the so-called “Millennials” or “Digital Natives”. Evidently, though, virtual worlds have not gained as much attention in university education as have other professional computer applications, the social media or user-generated encyclopaedias. Moreover, 3D worlds are often not recognized as a specific entity. Rather, they are often referred to as only a part of e-learning, which has caused some of the interest in the more exciting applications of 3D virtual worlds to stagnate.

3D virtual worlds and other virtual learning spaces are best understood as an alternative, not a replacement, to face-to-face communication and traditional teaching methods. They have many significant advantages compared to solely real-life learning spaces, some of which include the following:

1. Virtual worlds are extremely flexible, allowing

buildings and equipment to be placed, modified, expanded, and moved as needed.

2. Virtual worlds can be accessed at any time, and without real-life risks such as biological or chemical hazards.
3. Virtual worlds have low cost of operation and no cost at all for failed experiments. Furthermore, they allow repeating and rerunning the exercises, an important part of learning, for free.

Consequently, thousands of educators are currently exploring and using virtual worlds, of which Second Life has received most attention. Hundreds of colleges and universities, including Aalto University, have purchased and developed their own private islands in Second Life. It is a multi-user virtual environment developed by Linden Lab, mimicking real-life situations, with users represented by 3D characters called avatars.

2 BACKGROUND

2.1 General Advantages and Dis-advantages of Virtual Worlds in Education

The advantages and disadvantages of virtual worlds as means of education have been explored over a couple of decades. The most noteworthy advantages of virtual worlds in general, and of Second Life in particular, are listed above, namely flexibility of construction, freedom from real-life hazards, and low cost of operation and repeated exercises (e.g. Eschenbrenner et al., 2008; Holmberg and Huvila 2008; Palomäki, 2009). Information technology also helps adjusting the teacher to student ratio (Daniel, 2008), albeit this benefit is not exclusive to virtual worlds. Furthermore, virtual worlds have been proven to promote engaged learning, as discussed below.

Some of the disadvantages mentioned include the time needed to learn the use of the virtual world, high cost of development, technical issues such as frequent updates and out-of-date hardware, as well as attitudes towards such learning spaces, e.g. students or faculty not taking the virtual world seriously (e.g. Warburton, 2009; Palomäki, 2009; Inman et al., 2010). Moreover, according to Warburton, Second Life may be an isolating experience, since other users are not as easily found as in e.g. Facebook. In many ways this is an unfortunate truth, as at almost any moment of time, in almost any of its educational milieus, Second Life is empty; there is nobody around. The feeling of an eerie silence can easily discourage a newcomer.

2.2 Engaged Learning Promoted by Virtual Worlds

Engaged learning can be defined as commitment to a significant, in-depth, lifelong learning process, which extends beyond the classroom. Engaged learning is an integral part of all learning tools, verbal, digital, visual or emotional, which are used to increase personal and group commitment, regardless of prior success or talent thereof. Students learn in an environment that favours activity and experience and fosters immediate engagement (Biggs, 1999).

Virtual worlds in education have been shown to lead to increased engagement (Palomäki 2009). Brain activity has also been measured for tasks performed in real as well as in virtual reality environments (Mikropoulos, 2001). Findings have also demonstrated that subject are more attentive, responsive, and utilize less mental effort in the virtual world, demonstrating that knowledge transfer of information gained in one world to the other world is possible. Moreover, students have been reported to be more engaged in learning tasks and to spend more time thinking and discussing the subject material (Mason, 2007). Immersion into another world has also been noted and engaging in learning in the first person, which is more interactive and experiential (Richter et al., 2007). Moreover, previous studies have shown that as learners are allowed to interact with information in the first person, this facilitates constructivist-based learning activities (Dickey, 2005).

Furthermore, the interaction with virtual objects can be helpful in developing a stronger conceptual understanding, depending on the content. Engagement experiences are also present and by using virtual worlds as the learning environments enthusiasm for learning can increase. It has also been documented that the 3D virtual worlds facilitate the visualization of difficult content and offer tools for learning challenging concepts (Barab et al., 2000). The benefits of Second Life, in particular, include providing “a social laboratory where role-playing, simulations, exploration, and experimentation can be tried out in a relatively risk-free environment” (Graves, 2008).

2.3 Lablife3D: The Second Life Project of Aalto University

Practical skills are one of the core competencies in technology, engineering and the natural sciences. However, current laboratory courses are burdened by heavy expenses for modern and safe equipment and reagents, large course sizes and even waiting lists to the courses. Although learning-by-doing is the ultimate goal of practical laboratory classes and hands-on experimentation, the curriculum of many higher education institutions lacks space and time for the learning experience to mature. Many students pass classes with only superficial learning without developing deep learning where theory connects with practice. Accordingly, we have designed and implemented a virtual laboratory, LabLife3D, to bridge the gap between theory and practice. This is a pioneering project in the use of Second Life in the Finnish University setting. LabLife3D is housed in the Aalto Archipelago in Second Life virtual world. For more, see the home page of our project at https://sites.google.com/site/lablife3d/

To date, we have designed five laboratory "practicals" (Table 1). The virtual laboratory building, LabLife3D, was completed in late 2010, along with the first two exercises: a virus isolation simulation and an organic chemistry laboratory safety tutorial. The details of this development process, along with general considerations such as building the LabLife3D team, have been presented previously (Palomäki et al., 2010; Palomäki et al. 2011; Nordström et al., 2010). Later in 2011 and 2012, two further laboratory simulations were designed (Kangasniemi, 2012; Olkinuora, 2012). In addition, the design of a fifth practical, an organic chemistry simulation, has been completed, although its implementation has only recently begun. Similar to traditional laboratory classes, all the virtual exercises have been designed in accordance with learning goals and outcomes as described below. Besides creation of contents, we have also recently studied the pedagogical aspects of Second Life, namely with reference to the role of the teacher as a facilitator of group work and the responses of students to different ways of teacher facilitation.

Currently, in addition to the use of the simulations in microbiology and organic chemistry courses, the LabLife3D team is also collaborating with language teachers at Aalto University. The virtual laboratory is used as a teaching and learning platform for Swedish terminology of biotechnology and chemistry, helping the students in the challenge that multiple languages pose to them (Palomäki and Nordbäck 2012), as Swedish is the 2nd official language in Finland, and a compulsory language requirement in all university degrees.

2.4 The Other Existing Science-related Learning Environments in Second Life

Although Second Life has received considerable interest as a medium for academic education, relatively few of the numerous learning environments can be considered to represent actual simulations. Most of these settings mediate information only via passive elements, such as static 3D objects, sound and video. At best, they may include a chat conversation with an automated avatar possessing an artificial intelligence of some elementary kind. Active user participation, requiring decision-making or completing a set of tasks, is generally absent. These passive settings may be called 1st generation SL learning environments.

The simulation-type environments, or 2nd generation environments, can be readily classified in two distinct categories: ready-to-use simulations and teacher-initialized ones. As the name suggests, the teacher-initialized simulations are not executable to anyone at any time, but they can be participated only at scheduled times. They are most common in

Table 1: The laboratory exercises within LabLife3D.

	Theme	Status	References
1	Virus isolation	Operational from Dec 2010	Palomäki et al. 2010; Palomäki et al. 2011; Nordström et al. 2010
2	Laboratory safety tutorial	Operational from Dec 2010	*same as above*
3	Decarboxylation reactions	Operational from Oct 2012	Kangasniemi 2012
4	Virus identification by RT-PCR (*)	Operational from Jan 2013	Olkinuora 2012
5	Vacuum distillation	Design ready, implementing	- -

(*) RT-PCR = Reverse transcriptase polymerase chain reaction medicine, nursing and related fields, and they frequently engage multiple users in different roles communicating with each other. On the other hand, in the ready-to-use simulations, the user interacts only with the computer. This approach seems more typical to the laboratory simulations of natural sciences such as chemistry and biology. (Kangasniemi, 2012).

While constructing the Aalto University Second Life exercises we have been able to visit other Second Life laboratory simulations (Table 2). Many of the existing settings have allowed us to learn and experiment further in our own development activities.

2.5 General Design Objectives in Virtual Laboratories

Clearly, careful design of the content and the functions of virtual laboratories is essential to their success. The characteristics of an effective virtual laboratory for engineering students as described by Arango, Chang, Esche and Chassapis (2007) and Quinn (2005) have been summarized by Olkinuora (2012) as follows:

1. Context: The virtual laboratory should present a framework familiar to the students.
2. Realism: Clear connection between reality and the simplified model of the virtual laboratory.
3. A goal clear enough toward which to pursue.
4. No futile actions: The actions the students take should affect the outcome.
5. Exploratory feel: Enough possible alternatives and the possibility to explore their mutual relationships.
6. A slight degree of randomness to maintain curiosity.
7. Appropriate challenge: Not too easy but, not too difficult.
8. Appropriate feedback.
9. Relevance to other studies.
10. Visual appeal.

This list can be extended with avoiding cognitive overload, and the possibility of making actual errors without triggering an immediate response, in addition to the possibility of mere alternatives. Some of the above named properties are clearly complementary and can be implemented at the same time. On the other hand, others may partly contradict each other, as it is with exploratory potential and adequate randomness versus the need for no futile actions. Thus, the design process will involve compromises between the objectives.

Numerous experimental studies on different types of virtual learning have been conducted, with many of them reporting positive results but some also taking a critical stance towards the final outcomes (for review, see Mikropoulos and Natsis 2010, and Strangman et al., 2003). Although some of the studies relate to simulated laboratories (e.g. the 2D laboratory of Josephsen and Kristensen 2006), only very few of them refer specifically to virtual laboratories in Second Life.

The exception are The exception are Cobb, Heaney, Corcoran and Henderson-Begg (2009) who studied the educational performance of a virtual biotechnology laboratory, the UEL Lab (Table 2), in Second Life for learning the polymerase chain reaction (PCR) task ($N = 85$). Their results indicated

Table 2: A list of existing laboratory simulations in Second Life (not including those in Table 1).

Organization	Theme	Location in SL (*)
Leicester U.	Molecular biology	Media%20Zoo/74/189/32
Imperial College London	Respiratory medicine	Imperial%20College%20London/185/47/27
Monash U.	Manufacture of drug tablets	Pharmatopia/108/111/29
U. of Queensland	Mathematics in pharmacology	Pharmatopia/108/111/29
U. of Nottingham	Mass spectroscopy	University%20of%20Nottingham/176/130/26
U. of East London	Molecular biology	UEL%20HABitat/200/207/26
Keuda Vocational College	Mashing in a brewery	Edufinland%20IV/82/227/24
Florida Inst. of Tech. (**)	Physical chemistry	ACS/151/10/89
U. of Calgary (***)	Molecular biology	LINDSAY%20Virtual%20Medicine/187/194/29
Texas Wesleyan U. (****)	Biology	Genome/75/212/36

(*) All the SL locators are preceded by http://maps.secondlife.com/secondlife/
(**) The link and the simulation used in November 2011. Currently not online or closed to the public.
(***) Possible technical issues. The authors were unable to make the simulation work.
(****) A borderline case. Includes only limited elements of simulation.

that using Second Life did not significantly contribute to the learning outcomes. On the other hand, they did report that the Second Life test group performed better than the control group both before the experiment and after it. Hence, the conclusions are somewhat conflicting.

3 CONSTRUCTING THE AALTO UNIVERSITY LABORATORY SIMULATIONS

3.1 Desired Learning Outcomes of the Original Lablife3d Platform

When we first began to explore Second Life as a tool for teaching and learning biotechnology and chemistry, we focused on creating the actual space, the virtual building, LabLife3D. The primary learning outcomes that we wished to achieve all emphasized the promotion of deep learning via connecting scientific theory with practice. As a result of our earlier work, we created a microbiology exercise which allows the user to become familiar with working with viruses at a general level (Table 1). In addition, students could become familiar with the specific requirements for working in a clean room in addition to specialized culture techniques needed to grow viruses, which we are not able to carry out in a normal student laboratory.

Moreover, the focus of the original chemistry laboratory was on laboratory safety, which students could familiarize themselves with before the real-life practical class. In this setting, students learn to take into account sufficient number of safety features; protective clothing, correct cleaning of chemical spills etc.

More recently, however, we have become aware of a need to develop further our 3D experiments. Namely, it has been our objective to expand the experiments to better mimic the kinds of exercises that students typically carry out in the laboratory, where students also will need to make choices of which some also may lead to mistakes. Accordingly, we have designed a complete chemistry experiment on decarboxylation reactions (section 3.2) and a vacuum distillation experiment (section 3.3). In addition, in our first efforts to create experiments into Second Life, the microbiology practical on virus isolation was very focused on creating the appropriate laboratory spaces and becoming familiar with design of 3D worlds. It did, however, not offer a complete practical laboratory experiment. Consequently, we have recently added an experimental scenario, a molecular biology experiment, to our original virus exercise, as described in more detail below (section 3.4).

3.2 The Organic Chemistry Simulation on Decarboxylation Reactions

3.2.1 Learning Objectives, Content and Functions

Unlike the microbiology simulation and the laboratory safety tutorial built previously, the organic chemistry simulation (Kangasniemi, 2012) is not a strict laboratory practice exercise. Instead, it mimics experimental research at a more general level, with the main focus on teaching scientific reasoning based on empirical results.

In the simulation, the task of the student is to compare the reactivity of different carboxylic acids towards decarboxylation and decarbonylation and to deduce the theoretical explanation for the observations. The reaction variables (temperature, time, catalyst and solvent in addition to the acid substrate) are freely selectable from the alternatives given. The simulation is controlled by clicking on the chemical containers and instruments, such as the synthesis station and a balance, in the laboratory 3D space. In addition, there is a control panel for general functions such as “Start” and “Exit”. Instructions to the student are given in the HUD (see Figure 1).

3.2.2 Design Objectives and Process

During the design process, there were four matters of special concern. First, it was important that the simulation should not be too straightforward to pass: instead of being a demonstration, it should include alternative outcomes or the possibility of making true errors, or both. Although the organic chemistry simulation does not include the possibility of explicit errors, the array of different setup combinations, and hence reaction outcomes, is large (180 combinations in total). Moreover, the simulation leaves the planning of the research program to the student. All different reaction combinations are selectable, but it is not fruitful for the student to change the parameters without really thinking about the consequences.

Second, we analyzed the features of scenarios created by other groups (Table 2). From the usability point of view, the most important observation concerned the user interface in general. All the

To calculate the yield in mol-%, the structure needs to be known. Using the instructions as help, please choose the correct structure.

Figure 1: Screenshot: The organic chemistry simulation on decarboxylation reactions. HUD window on the left.

existing simulations require the use of the technical elements of Second Life, such as notecards, inventory, chat and the multiple choice popup windows. Some simulations rely on them heavily. However, in our experience, these elements frequently confuse the beginner. Therefore, it appears that it may be more beneficial to encode the operations to the more intuitively understood 3D space whenever possible, and leave the use of the technical elements to the minimum – even if this slightly decreases photographic realism.

Other very useful examples were the control panel designed by Florida Institute of Technology (Table 2) and the precise instructions given by the HUD, as used in the University of Leicester's virtual laboratory (Table 2). The possibility of the simulation happening in real time instead of symbolic time is also interesting, as presented in the SL Chemistry Lab of FIT (Table 2). However, due to the long reaction times in the present experiment, the dimension of time was not included in the simulation.

Third, wherever possible, our organic chemistry simulation gives the student real experimental data from the literature instead of extrapolations. This proved to be, in fact, by far the hardest part of the whole design. While suitable data for the experiment could be found from the literature, finding a complete set of results, encompassing all the combinations of every acid substrate, every temperature, etc., turned out to be impossible. Therefore the alternatives had to be chosen carefully to maximize both the presence of real data points as well as to ensure the reliability of the extrapolations. Finally, we decided to add the element of random experimental variation (1 to 5 %-points) to all measurements the student makes in the simulation.

3.3 The Organic Chemistry Simulation on Vacuum Distillation

3.3.1 Learning Objectives, Content and Functions

At the present time work is on-going on modelling a vacuum distillation in a laboratory setting. In contrast to the previous organic chemistry simulation (section 3.2), the newer one mimics the hands-on actions and operations in the laboratory very closely.

Vacuum distillation was chosen as the topic of the simulation for a three main reasons. First, vacuum distillation is an actual exercise taught at Aalto University organic chemistry laboratory courses. Moreover, building and operating the system in real life is quite a complicated task for the first-timer, involving even slight risks such as water spills and broken distillation pieces (expensive). Therefore, learning the process first with a detailed 3D simulation should offer substantial help. Finally, there is a possibility of making a wide range of mistakes in the simulation, giving a sense of realism.

The simulation is divided into three phases. First, the glass apparatus is assembled by clicking on the pieces on the table. In the next phase, the student connects the hoses for cooling water and suction. Here, all possible flawed connections are possible without triggering an immediate notice, but the configuration is checked by requiring the student to turn on the cooling water before proceeding. Almost all errors lead to water spill and reset. The final phase, heating and distilling, happens within a dimension of time. In this phase, a number of switches are operable: the heating plate, the pump and its valves, the 3-way joint, and the manometer valve. If the system is correctly assembled, boiling will commence once the oil bath is hot enough. The simulation will end after enough distillate has been collected.

3.3.2 Design Objectives and Process

The design objective was to make the simulation as realistic as reasonable and possible, with maximum freedom to control the switches in real time and in a free order. However, some compromises had to be made in order to limit the array of erroneous alternatives. Checking the hose connections by requiring the cooling water to be turned on first was one such limitation, fitting well to the storyline of the exercise. The level of modelling the physical state of the distillation system was also constrained to a certain extent. Temperature and time are modelled in a continuous manner, with the time-profiles of temperature being based on real measurements. However, pressure and the rate of collecting the distillate are modelled simply as on/off variables.

During the design process, it was found that pseudocode, comprising of `if`, `else` and `while` clauses, was a convenient way to express some critical parts of the simulation to the programmers. The basic setup was described in natural language, though. To familiarize themselves with the topic, the programmers also followed and recorded a real-life vacuum distillation exercise.

3.4 The Molecular Biology Simulation on Identifying a Virus with Reverse Transcriptase PCR

3.4.1 Learning Objectives, Content and Functions

The primary learning outcome of the molecular biology simulation (Olkinuora, 2012) is to give the student the opportunity to learn the process of identifying a virus from a human cell sample. The virus being studied is an enterovirus, identified in accordance to standard scientific methodology, based on a specific enterovirus protein known as VP1. Another aim is to encourage critical thinking of the choice of methodology and the reactions thereof. Many phases in molecular biology exercises are embedded into chemical reactions and the aim is therefore to deepen the students understanding of the intricate relationship between biology and chemistry.

Upon entering the laboratory an introduction and short instructions are given for performing the task. Avatars will wear appropriate clothing: lab coat and gloves. The objects mentioned below work by clicking on them. The task begins with extracting RNA from a sample of virus from a host cell culture (Figure 2). Buffer is added, incubation and centrifugation are performed, and a DNA-decomposing enzyme, DNase, is added to recover pure viral RNA after a series of extractions and centrifugations. The polymerase chain reaction (PCR) is then performed, followed by electrophoresis to visualize the sample and to verify that the experiment is proceeding as planned. In each of the aforementioned steps, the student must choose the correct process conditions such as the amounts of chemicals and temperature cycles for PCR. This requires the student to familiarize himself/herself with the principles that form the basis of the operations. At some points a text may appear which will highlight the reason for the choices that need to be made.

Having verified the success this far, the sample is sequenced. As most laboratories outsource sequencing these days, no sequencing scenario was designed and the correct RNA sequence is delivered to the student, provided that the extraction of the RNA has been successfully performed. In the final phase, the student submits the sequence of the virus to a real-life online gene database, BLAST (http://blast.ncbi.nlm.nih.gov/) to search for a match.

At the end the student gets a printout of all the steps done and is asked to write a report on the exercise for the teacher. It shows what happened to each object in each step, and the student can reflect on what was actually done in the laboratory. This reflection enhances the learning especially if mistakes had been made, as then it is very important that the student understands what the correct choice would have been and why.

3.4.2 Design Objectives and Process

The objectives in designing the user interface and the general structure of the molecular biology simulation were similar to those of the decarboxylation experiment (section 3.2), although the content and the desired learning outcomes were different. That is, the simulation is not too simple to

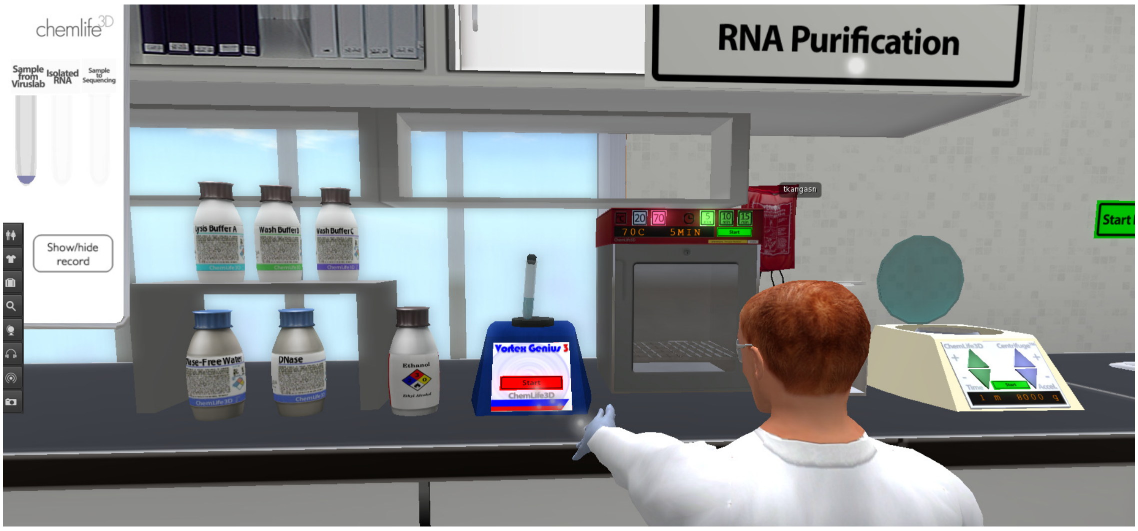

Figure 2: Screenshot: The molecular biology simulation. HUD window on the upper left.

pass, its active elements are embedded to the 3D space if possible, it uses real data, and adds random experimental variation. In addition, as already noted, there is a possibility of making real mistakes without receiving immediate notice. It was also decided that the actions taken in the virtual laboratory should include some simplification to avoid cognitive overload (e.g., not all details of pipetting modelled). The content of the simulation was presented to the programmers with the help of a flowchart, representing the state of the virtual objects.

4 USER INTERFACE TESTING: TECHNICAL AND PEDAGOGICAL VIEWPOINTS

4.1 Usability Testing: Heuristic User Interface Evaluation

As part of our aims to develop sophisticated laboratory experiments in Second Life, a formal usability test was conducted on the user interface of the organic chemistry experiment (section 3.2) in addition to normal troubleshooting. The test was designed and conducted by personnel not otherwise involved with the simulation (Tiitu, unpublished).

The test method used was the heuristic evaluation (Nielsen, 1994). Its benefits are the relative speed and ease of carrying out the test, while being able to effectively find both small and large usability issues. Three evaluators completed the test, all of them having little prior experience with Second Life. The test was performed in two separate sessions about two and half hours each. The evaluators began with getting familiar with SL, followed by performing the experiment individually and making notes on the usability issues. Finally a subjective assessment was given on the severity of the problems found. An instructor not contributing to the evaluation was present.

Evaluators were given a list of general points of focus called heuristics, to help them to recognize and categorize the possible shortcomings. The heuristics were divided in two sets: (1) technical and (2) pedagogical usability. In the following, the emphasis is on the technical usability, referring to the technical properties of the user interface and the ability of the evaluator to use the programs. The heuristics of technical usability used were modified from the original Nielsen's (2005) heuristics for evaluating specifically e-learning environments (Sampola, 2008).

1. Is the status of the system visible?
2. Is the language understandable to each user?
3. Does the user have an appropriate freedom to control navigation and operations? Is navigation simple enough?
4. Is the system logical and standardized?
5. Can mistakes be prevented? Are the error messages understandable?
6. Can objects and functions be readily identified, rather than requiring memorizing?
7. How much flexibility to modify the user interface there is available?
8. Is time spent efficiently?
9. Is the design aesthetically pleasing and/or minimalistic?

10. Is appropriate guidance available? In what format is it displayed?

The technical usability issues found were related to both the experiment in particular and to Second Life in general. Examples include virtual buttons not registering the click in some instances, inconsistencies in the instructions given by HUD, Second Life icons overlaying the HUD, and users knowing not how to e.g. zoom in the view in SL.

Besides identifying actual usability issues, our goal was to construct a more general checklist for performing similar tests in future. The list includes the setup of test session as stated above, plus practical notions, of which probably the most important is making sure beforehand that the computers and programs work well. A convenient size for the test group is three to five persons. This way some 50 % to 80 % of the existing usability issues can be found (Nielsen, 1993).

4.2 Preliminary Results of Student Assessment

Both the organic chemistry experiment on decarboxylation (section 3.2) and the molecular biology experiment (section 3.4) were assessed as course exercises by groups of 1st to 3rd year engineering students, who filled in anonymous feedback forms. However, at this time, analysis of the data is on-going and a preliminary summary is presented below.

Each exercise session was facilitated by a teacher with background in the core subject and experience in using Second Life. The feedback forms were designed by personnel other than the teachers and SL designers as part of two on-going M.Sc. theses (Brusin and Virtanen). The same individuals also monitored the teacher–student interactions in each group. At this time, no comparative studies between the test groups and a control group were carried out.

Organic chemistry exercises were performed in four groups (two simultaneous groups at two times). A marked difference was noted between the two time slots. The students in Monday groups (*N* = 13) felt, in general, that the experiment was reasonably interesting and supported previous knowledge to some extent. They also felt actually having learned something new and said that they understood the scientific objectives. However, the students stated that it was possible to pass the simulation without really thinking much (Table 3).

On the contrary, the Friday groups (*N* = 16) were much more critical. About half of the students reported they were not interested at all in the exercise, did not grasp its purpose and felt they did not learn anything. Moreover, unlike the previous group, they admitted actually exploiting the possibility to pass the task mechanically without thought (Table 3). The notes made by the observers support these differences. The fact that the Monday group had better IT skills and more prior experience with virtual worlds should explain some of these differences. In addition, the Monday group was, on average, more advanced in their studies. In student life, the day of the week (Monday vs. Friday) may have a role to play, too!

Overall, 97 % of the students replied that the most convenient way to interact with the teacher was face-to-face discussion, instead via their avatar.

In contrast to the rather mixed feedback from the organic chemistry exercise, the student response from the molecular biology exercise was unanimously positive, even though the students were no more familiar with virtual worlds. An updated version of the feedback questionnaire was used, though. The exercise was conducted in two simultaneous groups of 10 students each as part of a 2nd year microbiology course. The students reported they had clearly understood the assignment and also most of the actions taken during exercise. A majority thought having learned something new, albeit not very much. The level of scientific challenge was considered appropriate (Table 4).

Table 3: Key figures from the student assessment of the organic chemistry experiment.

Question (option A / B / C)	Monday Groups			Friday Groups		
	A	B	C	A	B	C
Experience with virtual worlds (none / some / much)	31%	54%	15%	63%	25%	13%
Desired outcome understood? (no / in part / completely)	0%	54%	46%	47%	53%	0%
How much did you learn? (nothing / some / much)	8%	85%	8%	56%	44%	0%
Supported previous knowledge? (no / slightly / well)	15%	85%	0%	56%	44%	0%
Possible to pass without thought? (no / yes, chose not / yes, did so)	15%	77%	8%	0%	31%	69%
Change of attitude during exercise (negative / none / positive)	8%	54%	38%	6%	69%	25%

Table 4: Key figures from the student assessment of the molecular biology experiment.

Assertion	Strongly disagree	Disagree	Agree	Strongly agree
I am familiar with virtual worlds.	45%	35%	5%	15%
I understood the assignment.	0%	0%	30%	70%
I learned new things.	0%	5%	75%	20%
I understood all the actions taken in the exercise.	0%	15%	70%	15%
The difficulty level was appropriate.	0%	15%	35%	50%
My attitude changed more positive during the exercise.	5%	16%	63%	16%

It therefore appears that the molecular biology simulation was either better designed from the pedagogical point of view, or better connected to the course contents than the organic chemistry simulation was – or both. The scientific content of the latter may have been too difficult, and the structure of the simulation too straightforward.

However, the difference may not be entirely due to the content of the simulations themselves. Although both exercises were voluntary, giving extra points to the exam, the inclusion of the molecular biology exercise was announced at the very beginning of the course, with an essay as an alternative. For the organic chemistry course, the SL exercise was just an extra. The former setup may have helped the students take the exercise more seriously, as part of the learning outcomes of the whole course, instead of thinking it just as means of collecting a point to the exam.

4.3 Evaluation of the Teacher's Role

We are also currently studying the role of the teacher as a facilitator of student learning in Second Life. Notably, to our knowledge, there are no previous systematic studies on what the role of the teacher should be. We are therefore in the process of elucidating if teacher roles as facilitators differ from roles that have been studied in context of problem based learning (Kolmos et al., 2008).

Our preliminary observations suggest that the role of the teacher as a facilitator for a Second Life experiment may not as be as important as e.g. the design of the virtual exercise and student motivation. In the molecular biology exercise, students responded quite similarly in both groups, even though the teachers had a distinctly different style, the other instructing in a more active and authoritarian manner, and the other leaving much more time for independent work. In the organic chemistry exercise, the teachers' styles did not differ much from each other, and thus no significant comparison could be made.

5 CONCLUSIONS

The aim of our virtual biology laboratory experiments is to mimic the work of a real-world scientist in the fields of chemistry and molecular biology and thus support linking theory with practice. Moreover, we wish to provide students with tools that may deepen the learning process as an additional tool to learning in the real-life wet-lab. From the learning outcomes recognized in virtual teaching laboratories by Strangman et al. (2003), content area knowledge and conceptual change could be expected to be an outcome of the virtual world experiments that we have designed.

Contrary to Helmer (2007), who argues that too much similarity with the real world might be seen as distracting and disadvantageous for learning, we feel that a high degree of photographic realism adds to student motivation to use virtual tools for learning. Our experience with students suggests that sufficient freedom of operation is probably very important, too. A simulation too straightforward to pass does not provoke the necessity to think one's actions.

As stated by Josephsen and Kristensen (2006), real life student laboratories may actually place too much emphasis on procedural tasks which possibly lead to a cognitive overload for the learner and therefore may even hinder the learning process. In order to overcome such drawbacks, we have specifically worked on minimizing the attention to detail and focusing on the order of steps and the interpretation of data.

Furthermore, the experiments should have a clearly defined goal and the goal should link theory to practice and to scientific research methodology. Our experience implies, too, that the exercises should be clearly tied to a context, meaning not only a connection to the theoretical course matter but also having a sensible function as a part of the course.

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SHORT PAPER

Development and Evaluation of the ‘Pocket Plant Guide’ to Support the Observation and Identification of Indicator Plants for Vegetation Succession

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Keywords: Mobile Systems, Outdoor Learning, Science Learning.

Abstract: We developed and evaluated a mobile system called ‘Pocket Plant Guide’ for support the observation and identification of indicator plants for vegetation succession. One characteristic of the ‘Pocket Plant Guide’ is that it uses sketches instead of photographs. This guide contains 3 representative functions that help students in identifying and observing of indicator plants. These functions include (1) coloured representations of leaves and fruits; (2) enlarged images of leaves and fruits; and (3) sketches of the backside of the leaves. We allowed Japanese sixth grade elementary school students (age 11–12 years) to use the ‘Pocket Plant Guide’ to identify and observe indicator plants. After this activity, we used a questionnaire to evaluate the ease with which the students used the guide, and validated the usefulness of the guide for identifying and observing indictor plants. The results indicated that the ‘Pocket Plant Guide’ was quite easy to use and was effective in supporting the identification and observation of indicator plants.

1 INTRODUCTION

In the area of the science education, an important aspect of studying plants is to observe these in nature, in addition to accumulating classroom knowledge. However, field identification and observation of plant types or names is often difficult when using a large textbook. In recent years, research has been conducted on using a mobile device to support the identification and observation of plants. Previous studies have shown the effectiveness of mobile devices in identifying and observing plants (Morita et al., 2004; Huang et al., 2010). Kusunoki et al., (2011) initiated the development ‘Pocket Plant Guide’ as a mobile system to support the efforts of students in identifying and observing indicator plants. The ‘Pocket Plant Guide’ is a system designed to present information on 12 types of representative indicator plants during the early, middle, and late stages of vegetation succession using an iPhone/iPod Touch platform. The indicator plants used in the guide were selected from vegetation succession studies conducted in the Rokko Mountains of Kobe, Japan. While previous systems used photographs, the ‘Pocket Plant Guide’ uses sketches, which is one of its defining characteristics. As is often stressed in scientific practice, scientists alter the natural world in some way to facilitate the observation of subjects, (Lynch, 1990). Scientific activity, such as the identification and observation of plants, are usually accomplished through sketches instread of photographs and this is because it is easier to visualise the characteristics of plants as a drawing, compared to photographs.

Inoue et al. (2012) conducted a preliminary evaluation of the pilot version of this guide. The results of this initial study indicated that the guide was effective in supporting the identification and observation of indicator plants. In addition, we obtained suggestions towards further development of the contents and interface for the current version of the guide.

We completed the development of the ‘Pocket Plant Guide’ by incorporating the feedback from the preliminary evaluation. The purpose of this study was to determine the ease of use of the ‘Pocket Plant Guide’ and to determine its effectiveness in supporting the identification and observation of indicator plants.

2 OUTLINE OF THE ‘POCKET PLANT GUIDE’

Figure 1 shows the home screen of the ‘Pocket Plant Guide’. Six types of indicator plants are shown as icons on this screen. Flicking the screen to the left reveals the remaining 6 types of indicator plants, also shown as icons in Figure 2. The teacher explained to the students that in order to display the remaining 6 types of indicator plants, the screen should be flicked to the left. When one of these icons is tapped, for example, *Rubus microphyllus*, a monochromatic sketch of the indicator plant in Figure 3 appears.

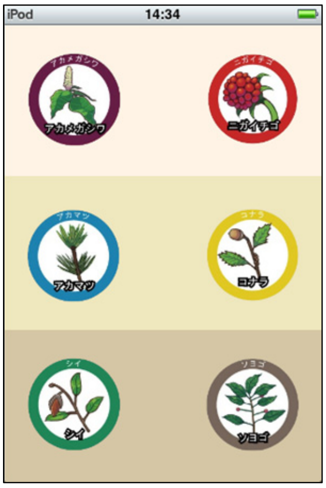

Figure 1: Home screen of the ‘Pocket Plant Guide’.

This guide includes 3 fundamental functions that support the identification and observation of indicator plants. First, the characteristic parts of the indicator plant are shown as colour sketches. This function helps to identify indicator plants that have distinct leaf or fruit colour features. If the user taps the monochromatic sketch in Figure 3, the characteristic parts of the indicator plant are shown in colour, and a comment describing the characteristic is displayed at Figure 4. In this colour sketch, the characteristic red fruit of *R. microphyllus* is shown.

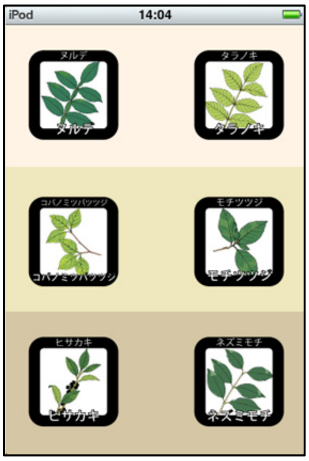

Figure 2: Screenshot of the remaining 6 types of indicator plants.

Figure 3: Screenshot of the monochromatic sketch of characteristics of the indicator plant.

A second function is the ability to enlarge the leaf and fruit sketches of indicator plants. This feature was included to support the identification and observation of indicator plants that have characteristic leaf shapes or leaf veins. If the loupe icon is tapped at the bottom of Figure 4, an enlarged leaf is shown. Figure 5 shows the upper side of the enlarged leaf of *R. microphyllus*. The characteristic 2 large notches of its leaf are shown. Tapping the x button at the top right corner of the screen returns the user to the previous screen (colour sketch).

Third, users are able to examine the backside of a leaf by rotating the indicator plant leaf. This feature may be used to identify and observe

Figure 4: Screenshot of the colour sketch of characteristics of the indicator plant.

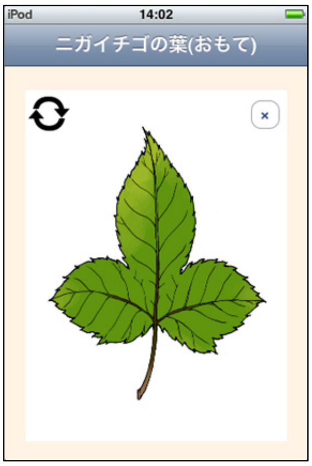

Figure 5: Screenshot showing the upper side of an enlarged leaf.

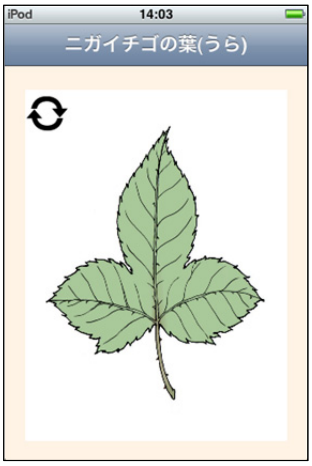

Figure 6: Screenshot showing the backside of an enlarged leaf.

characteristic leaf shapes and vein structures on the backside of indicator plants. If a user taps the enlarged image of the upper side of the leaf in the Figure 5, an enlarged image of the backside of the leaf appears. Figure 6 shows the backside of *R. microphyllus* leaf. The characteristic white colour of the backside of the *Rubus microphyllus* plant leaf is shown on this screen. Tapping the screen once more returns the user to the previous screen (upper side of the leaf).

3 EVALUATION OF THE ‘POCKET PLANT GUIDE’

3.1 Evaluation Method

3.1.1 Purpose

The purpose of evaluation was two-fold: (1) to determine whether the ‘Pocket Plant Guide’ is easy to use for elementary school students, and (2) to determine the efficacy of the ‘Pocket Plant Guide’ in supporting elementary school students in identifying and observing indicator plants.

3.1.2 Subjects

The subjects were 35 elementary school students (age range: 11–12 years) from an elementary school attached to a Japanese national university.

3.1.3 Task

The research task was to evaluate the ease-of-use of the ‘Pocket Plant Guide’ and evaluate its efficacy in supporting the identification and observation of indicator plants. The questionnaire contained 13 questions, of which 7 were related to the ease-of-use of the ‘Pocket Plant Guide.’ Sample items included ‘I could easily touch/tap the screen with my fingertips’ and ‘I could easily manipulate the plant sketch screen to the more detailed characteristics screen.’ The remaining 6 items addressed the 3 characteristic functions of the ‘Pocket Plant Guide’ and its efficacy in identifying and observing indicator plants. For example, with respect to the coloured sketches of the indicator plants, items such as ‘the coloured sketches helped me identify the real plant’ were included. For each of these items, students were asked to select one of the following 4 options: I think so, I mostly think so, I don’t quite think so, and I don’t think so. Printed questionnaire sheets were distributed.

3.1.4 Procedure

The students were divided into groups of 6 and were asked to identify and observe the 12 types of indicator plants in the guide. The activity was conducted indoors. Each student was given the ‘Pocket Plant Guide’ for use. The activity time was approximately 20 min. After the identification of indicator plants, the students were asked to answer the questionnaire, which took approximately 15 min. The evaluation was conducted on November 17, 2012.

3.2 Results

Table 1 shows the students’ response to each item in the questionnaire. We interpreted the responses ‘I think so’ and ‘I mostly think so’ as positive responses, whereas ‘I don’t quite think so’ and ‘I don’t think so’ were classified as negative responses. We then performed Fisher’s exact test to identify patterns in the students’ responses.

First, we discussed the results of the 7 items in terms of ease-of-use. In 6 out of the 7 items, significantly more students answered positively than negatively ($p < 0.01$). However, for item 6, no significant differences were observed between the number of students that answered positively or negatively ($p > 0.10$).

Next, we examined the results of the evaluation for the 6 items related to the guide’s efficacy in supporting the identification and observation of indicator plants. For all 6 items, significantly more students answered positively than negatively ($p < 0.01$).

4 CONCLUSIONS & FUTURE WORK

We developed and analysed the ‘Pocket Plant Guide’ in this study. The characteristic functions of this guide are: (1) the colour display function of leaves and fruits; (2) the enlargement function of leaves and fruits; and (3) the backside view of leaves.
First, we discussed the ease-of-use of the guide. The results of the assessment showed that the number of positive responses was significantly higher for all but one item indicating the ease of use of the ‘Pocket Plant Guide’ by the students. However, no significant differences between the positive and negative responses for the questionnaire item ‘I can easily switch from the enlarged image of leaves and fruits to the screen showing the plant characteristics.’ were observed. One reason for this was that the button to return from the enlarged sketch of leaves

Table 1: Assessment of the ‘Pocket Plant Guide’.

Ease-of-Use	ITS	IMTS	IDQTS	IDTS
01 I can easily touch/tap with my fingers **	14	14	7	0
02 I can easily switch from the plant selection screen to the plant sketch screen **	25	9	1	0
03 I can easily switch from the plant sketch screen to the screen showing plant characteristics **	20	12	3	0
04 I can easily switch from the characteristics screen to the enlarged images of fruits and leaves by tapping the loupe icon **	20	11	4	0
05 I can easily rotate the sketches to view both sides of the leaf **	18	9	7	1
06 I can easily switch from the enlarged images of leaves and fruits to the screen with the plant characteristics *	15	7	9	4
07 I can easily switch from the characteristics screen to the plant selection screen **	25	6	3	1
Effectiveness in plant identification and observation	ITS	IMTS	IDQTS	IDTS
[For sketches with coloured plant parts]				
08 It helped me to find the real plant **	27	7	1	0
09 It helped me to observe the real plant and its characteristics in detail **	24	10	1	0
[For enlarged sketches of leaves and fruits]				
10 It helped me to find the real plant **	26	8	1	0
11 It helped me to observe the real plant and its characteristics in detail **	25	10	0	0
[For rotatable images of leaves that allow the student to view both sides]				
12 It helped me to find the real plant **	21	8	5	1
13 It helped me to observe the real plant and its characteristics in detail **	19	13	2	1

$N = 35$; **$p < 0.01$; *n.s: not significant; ITS: I think so; IMTS: I mostly think so; IDQTS: I don’t quite think so; IDTS: I don’t think so and fruits to the screen with their characteristics was too small. In the future, further improvements to the interface of 'Pocket Plant Guide' will be necessary.

Next, we discussed the efficacy of the guide in supporting the identification and observation of indicator plants. For all items, the number of positive responses was significantly greater. We speculate that the following 2 factors affected this outcome: (1) sufficient information was included in the 'Pocket Plant Guide' that allowed the students to identify indicator plants by the colour of its fruits or leaves or the shape of the upper and backside of the leaves; and (2) a sufficiently permissive environment for the observation of plant characteristics was obtained through the coloured and enlarged sketches contained in the guide. On the basis of these observations, we conclude that the 'Pocket Plant Guide' is an effective tool in supporting the identification and observation of indicator plants.

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POSTERS

Development of a Skill Learning System using Sensors in a Smart Phone for Vocational Education

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Keywords: Vocational Education, Skill Learning, Smart Phone, Feedback Own Movement.

Abstract: Generally speaking, learning or teaching requires time, particularly with physical movement. In this paper, we demonstrate an efficient way for students to learn skills by using sensors in a smartphone. Every smart phone has some type of sensors e.g. acceleration sensor, gyro sensor and so on. Our “Skill Self Learning System (SSLS)” can give feedback, results and evaluation of a student’s actual movement to his/her self immediately on the smart phone, which he/she is using. In this research we used SSLS for learning how to saw and plane. As a result of running simple tests, a group using SSLS could improve their skills as well as a group, which a teacher taught in person. According to the results, if students have learned the skills before an actual class, a teacher can teach skills in detail and support them interactively. Our method is beneficial for enhancing traditional vocational learning as well as for distance skill education, intelligent skill learning and teaching system.

1 INTRODUCTION

For efficient learning, it is considerably important for learners to have knowledge about the contents before their class. Flipped-learning is one typical approach. The flipped learning/teaching method is defined as follows, according to Wikipedia (2011):

> “Flip teaching is a form of blended learning which encompasses any use of Internet technology to leverage the learning in a classroom, so the teacher can spend more time interacting with students instead of lecturing”.

Moreover, Berrett (2012) mentions the benefit of the learning style. As a background, the important point made is that time is too short to learn only in face to face class environment. Needless to say, this problem occurs in skill learning as well. It is a particularly serious problem for Japanese junior high school students who do not have real experience (Ando and Abiko, 2003). In this paper, we focus on vocational learning, and the subject is technology-education in Japan. In Technology-Education, students learn to “make things” such as the craft arts (woods, plastics and metals), electricity, metal craft, materials, changing energy and Information Technology. In the Japanese education system, the subject is allocated only one class per week and is found only in Junior high school education curriculum. Therefore, not only have almost all students never tried to use craft tools e.g. a saw and a plane, but also they don’t have enough time to learn its skill. In spite of the fact that these are basic skills in Technology Education, a lot of students have never been good at making things (Yamamoto et al., 2007). Obviously, the unique circumstances around students are changing. Competently, most students don’t feel the need to make things in their life. However the experience of making useful products according to their own design affects not only national power, but also desired character formation (Ando et al., 2011). It is commonly known that learning skills to use tools requires the necessary equipment and right conditions. Unfortunately, such tools, i.e. a saw and plane, are not readily available in students' home. Moreover, most parents themselves aren't good at these skills, therefore the students cannot understand if their posture and movement are correct or not. MEXT (Ministry of Education, Culture, Sports, Science and Technology in Japan) (2011) says teachers should make students into well-learned citizens, however a concrete teaching program hasn't been developed to meet such a need.

On the other hand, there exists research regarding the usage of sensors to understand a user's state or action. For instance, Hattanda et al. (2008) has tried to develop new functions of a cell-phone in which the screen changes automatically in response to adapting to user actions. In this work, it required acceleration sensor hardware connected outside of the cell-phone. At around this time, sensor devices had been the focus of mobile devices. In the educational field, Kashiwagi et al. (2010) began to research the use of a few acceleration sensors and slant sensors attached to a students' head, both sides of wrists, both sides of ankles and waist. These sensors were hardware which could transmit data to a PC. Using this system, an observer could know how students behaved from a distant place.

The originality of our work is in using a smartphone instead of special devices. All smartphones are equipped with acceleration sensors, slant sensors and gyro sensors. Though it is possible that special sensors may be far more precise than sensors in a smartphone, we haven't found practical reports for the investigation of a user's condition by using a smartphone. Moreover, we haven't found any previous research that exists regarding an application of a smartphone to learn or improve a students' skill. Our research question is sensing data from sensors in a smartphone that can enhance the students' skills. As we described, there are serious problems in vocational education. If this approach is developed, students' are able to learn, practice and improve their skill without a teacher and special classroom. Former models of smartphones are less expensive and even an obsolete model can be used in this approach.

In this research, we aimed to develop a "skill self-learning system (SSLS)" and evaluate the approach for beginner subjects to improve their skill. We described a beginner's typical mistakes of sawing and planning. Then, we suggested the necessity of self-skill-learning and advantages of using a smartphone. Finally, the results of a simple experimentation by using our developed system were discussed.

2 TYPICAL FAILURE SITUATION FOR A BEGINNER

Sometimes, typical failure situations appear while beginner students practice their own skill without the aid of a teacher. Situations may be errors such as the wrong strength or incorrect movement. Japanese official textbook (2012) for technology and vocational education says “While sawing, set the blade as shown, like a straight line” and the other textbook says “to cut straight, place the blade underneath, between the eyes”. In addition, the textbook says “the angle between a wood piece and a blade should be from fifteen to thirteen degrees”. When sawing, a blade should be moved forward and backward repeatedly while keeping the blade vertical. According to practical experience, a beginner tends to fail to correctly do the three patterns as follows; first, a worker cannot set and keep the blade at the proper angle. The second, while moving the blade, it leans to the side and it isn't kept vertically straight. The last, the blade is moved irregularly. Unfortunately, a beginner cannot be made aware of these typical failures unless someone tells them.

In the case of using a “plane” to flatten the surface of wood, it is difficult for a beginner to slide it at the proper speed. Moreover, at the beginning of sawing, the peculiar movement, which a plane is moved marginally to a backward direction, appears in the expert's movement. It is also hard for a beginner to understand how to coordinate his/her arms and his/her waist.

3 OUTLINE OF THE SYSTEM

3.1 Basic Function and Contrivance

Our original SSLS method is to use "smart-phone" instead of special sensors and analysing system. Every smart phone has some important features: LCD wide screen, gyro sensor, acceleration sensor, data storage and connection to the Internet. Our basic design allows students to attach a smart phone on a tool and assess their own skill without an expert by displaying feedback results. The SSLS works on devices installed with Android OS version 2.3 or greater. The SSLS is able to record and calculate data every ten micro seconds. This data represents the number of forward and backward motions, speed of moving, maximum speed, elapsed time, change of slant angle while moving, and the change of blur while moving.

In the case of sawing, the acceleration of the y axis and z axis is calculated using the three axis acceleration sensor of the smart phone, in order to count the number of times the blade moves forward and backwards. Figure 1 shows the actual results of an expert worker's sawing.

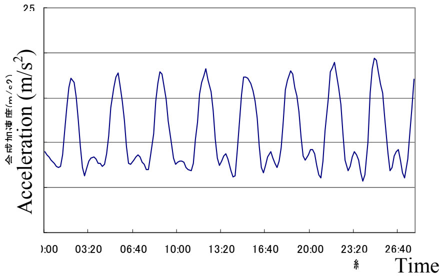
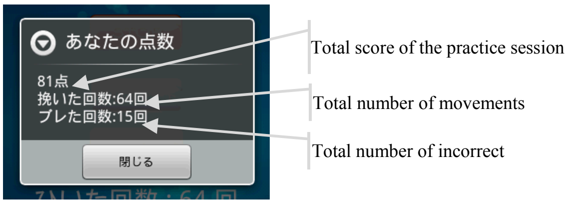


Figure 1: Change acceleration of an expert's sawing.

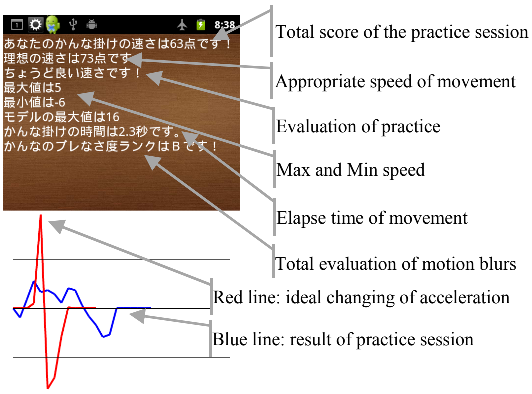
In this research, the threshold value for counting was fixed at 15(m/s^2). To record the slant angle of a blade, it uses values taken from the slanted sensors. After a few practice sessions, the application displays the initial results as feedback information to the student. By these results, a student can improve his/her own movement and skill (Figure 2). In the case of planning, the application shows the change of acceleration as a line graph comparing them with the results of an expert's movement, and feedback message regarding motion speed (Figure 3).



あなたの点数

81点
挽いた回数:64回
ブレた回数:15回

Figure 2: Result and advice for improving sawing.



あなたのかんな掛けの速さは63点です！
理想の速さは73点です
ちょうど良い速さです！
最大値は5
最小値は-6
モデルの最大値は16
かんな掛けの時間は2.3秒です。
かんなのブレなさ度ランクはＢです！

Figure 3: Result and advice for improving planning.

3.2 How to Set up and Practice

In the case of sawing, a smart phone, which was installed with our application, is put on a bar of a saw with an attachment (Figure 4, left). To minimize the weight of the whole saw, the attachment is made of foaming polystyrene. In the case of planning, the smart phone is put on a wooden piece, like the body of plane (Figure 4, right). In both cases, hook-and-loop fasteners secure the smart phone to the tool. Figure 5 shows a practice motion and Figure 6 shows actual scenes of sawing and planning.

Figure 4: A smart phone put on a bar of a covered saw (left) and a smart phone put on a wood piece like a plane (right).

To begin a practice session, tap to run SSLS application for sawing. Before sawing, the student must adjust the proper angle between the blade and wood. Then tapping the start button, SSLS begins to record and analyse the acceleration of the smart phone. During practice, if SSLS detects improper or irregular motion, the smart phone screen changes colour from blue to red and beeps to indicate incorrect movement. After sawing, SSLS shows a summary of the practice results. However, in order to practice planning, a student has to watch a recorded example of correct planning posture beforehand. To record proper examples, tap the "record button" on the menu screen. In this record mode, SSLS can record whole movements of planning. Figure 7 and Figure 8 show each algorithm of practice.

Figure 5: Actual scene of sawing with a smart phone.

Figure 6: Actual scene of planning with a smart phone.

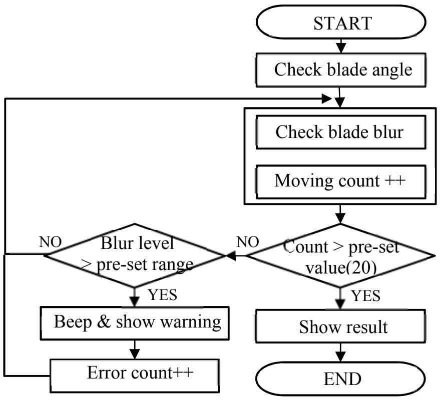


Figure 7: Algorithm in sawing practice.

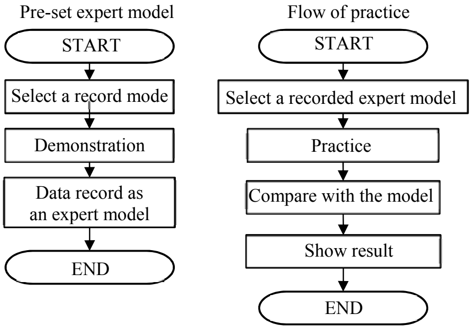


Figure 8: Algorithm in planning practice.

4 EXPERIMENTAL PROCEDURE

To evaluate our SSLS approach for improving students sawing skill experiment, we conducted test with seven university freshman subjects who were beginners, and we conducted test with six subjects who were high school students.

When sawing, the most important skill is to cut the wood straight and vertical. So, we compared changes of the blade's slant by using the SSLS and by a teacher's oral method (Oral teaching group). All subjects used a covered saw with the smart phone and practiced moving it forward and backward repeatedly twenty times. In the smart phone group, subjects checked their own results and feedback information on the smart phone during every trial. In the other group, a teacher instructed subjects of the oral teaching group during every session. Subjects of both groups tried this repeatedly five times. We compared the average acceleration of the sideward motion of the first result with average acceleration of the fifth result.

Next, in the case of planning, we compared the first and fifth sessions' acceleration values change of the blur made by the body of the moving plane. In this case, all subjects were in separate SSLS groups; Oral teaching group as well as sawing. Both groups consisted of three subjects.

5 RESULT OF PRACTICE TEST

Figure 9 shows the result of sawing test. In first instance, average acceleration of the blade was 0.61 (m/s^2) (SD=0.34) in SSLS group and 0.50 (m/s^2) (SD=0.28) in the oral teaching group, and at the last time, it was 0.56 (m/s^2) (SD=0.31). This result shows that only SSLS had significant differences ($t_{(603)}$ = 2.475, $p < 0.05$). It means that subjects improved by using SSLS. The first time however, there were already apparent differences of skill between the SSLS group and the textbook group. Subjects of the oral teaching group were already good at sawing. Therefore, we could not conclude that using SSLS was better than the oral teaching methods according to only this result.

Likewise, Figure 10 shows the result of planning test. It was found that both groups improved in blur of planning ($p < 0.05$). There were no significance differences between the Oral teaching group and SSLS group in both the first trial and fifth trial.

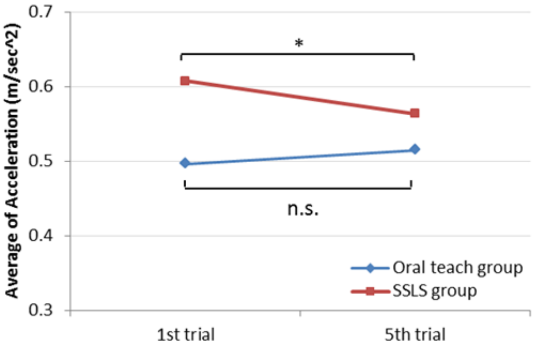


Figure 9: Effectiveness of practice sawing in proper slant.

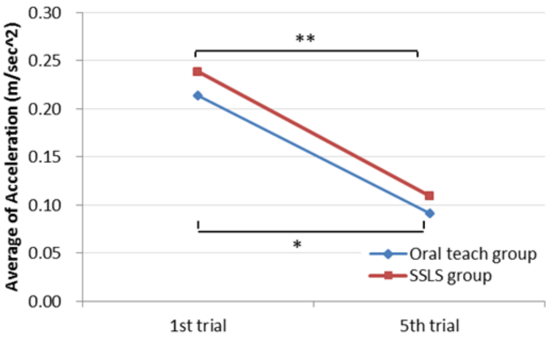


Figure 10: Effectiveness of practice in blur of planning.

6 DISCUSSION

According to these two tests, we found the students use of the smart phone while sawing and planning to be very effective in improving their skill. Though under the condition that subjects were beginners and the number of subjects was on a small-scale, it means that beginners can improve their skill of basic sawing and basic planning without the aid of a teacher. Even with such tentative results, we believe this to be meaningful even for distance learning and enhancing face to face classroom learning. Until now, e-learning has been used to acquire knowledge via text and visual aid e.g. videos and YouTube. As far as using a traditional method, students cannot understand and assess their skill without a teacher, i.e. they cannot avoid incorrect posture or improper movements without a teacher. Because of this problem, it is difficult for distance learning of skill based training. However using our method, students can understand how they should move their body or tools by themselves. Apparently, we have to validate our method using more subjects and improving the precision of data from the sensors. However, this method of using sensors on a smart phone and the resulting immediate feedback to students can enhance traditional learning not only in vocational education but also physical education and sports. Even though in this research, the number of subjects was low and limited, we could get appropriate results. Our research team has already applied the approach to about 80 actual junior high school students. We are going to report the effectiveness of the practice in detail in a next paper.

7 CONCLUSIONS

In this paper, we developed Self Skill Learning System (SSLM) using sensors in a smart phone. The system works on smart phones using Android OS. In terms of a student's actual practice, it can indicate results visually and advise on how to improve. We conducted sawing and planning experiments that are basic skills in vocational education. As our results showed, a group using SSLS could improve both skills. However as far as this research, we could not clearly conclude that SSLS was better than a teacher's oral method. Currently, we are developing Skill Learning Management System (SLMS) that can record students' results of practice and can compare those results to other students. Using SLMS, a teacher will be able to know who is good at a skill or not before lectures and it will help a teacher to make a priority of whom he/she teaches to.

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An Approach to the Electronic Textbook of Basic Chemistry Linking Chemical Experiments

CG Teaching Materials based on Quantum Chemical Calculation

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Keywords: Chemical Experiment, Teaching Material, Tablet Computer, CG, Visualization, Quantum Chemical Calculation.

Abstract: We tried to make CG teaching materials toward electronic textbook of basic chemistry linking chemical experiment for university student. The CG teaching materials could demonstrate the nature of the reaction such as structural change by ball-and-stick model or space filling model with electrostatic potential, and potential energy change by the reaction profile. The materials included 1) formation of di-atomic molecule such as hydrogen iodide, 2) hydroxylation of methyl chloride as a model of Walden's inversion. These CG teaching materials enabled to load with desktop, laptop, tablet computer, and smart phone. The CG teaching material of hydroxylation of methyl chloride was tried to combine with chemical experiments to make electronic textbook of basic chemistry.

1 INTRODUCTION

Chemistry is the subject that has been studied through the experiment. Understanding the observed phenomena, chemists use to imagine and explain observations in terms of molecules. Observed phenomena and molecular-level models are then represented in terms of mathematics and chemical equation. These three thinking levels of observable level, symbolic level, and molecular level, respectively was mentioned (Tasker and Dalton, 2010). Visualization is great help for students to have images of phenomena, chemical concepts, and molecular world. It is our aim to produce computer graphics (CG) teaching material, which provides realizable images of the nature of chemical reaction (Ikuo et al., 2006).

The reaction of simple molecule such as hydrogen halide and related compounds plays a fundamental role in the development of chemical kinetics and theoretical chemistry (Allison et al., 1995; Eyring and Polanyi, 1913; Sullivan, 1962). The reaction of equation (1) is often used for explanation of reaction rate and

$$I + H_2 \rightarrow HI + H \qquad (1)$$

chemical equilibrium in "Chemistry II" of Japanese high school (Sanseido, 2004). Generally, reaction profile is used to represent relationship between potential energies (PE) and reaction coordinate. The profile is often used in high school chemistry textbooks (Daiichigakusyusya, 2004; Jikkyosyuppan, 2004; Keirinkan, 2003; Sanseido, 2004; Tokyosyoseki, 2004). It is sometimes difficult for student to realize the meaning of reaction coordinate in the profile because of the representation by a diagram of PE surface in two-dimensions (PE-2D) except the rare case of rough sketch of analogues in three-dimensions (PE-3D) in physical chemistry textbook of university (Atkins and Paula, 2002; Moor, 1982). Also images of synchronization with successive changes of the structure of objective molecules and distribution of electrical character can provide clear images of the reaction.

We developed CG teaching material based on quantum chemical calculation of chemical reaction for university student, which can be used to desktop, laptop, and tablet computer, as well as smart phone. This paper introduces our works of CG visualization of fundamental chemical reactions for realizing certain images of the reaction mechanism and an approach to the electronic textbook of basic chemistry linking chemical experiments, which integrates the observable level experiment and the molecular world.

2 PROCEDURE

2.1 Quantum Chemical Calculation

The semi-empirical molecular orbital calculation software MOPAC (Stewart, 1989a, b, 1991) with AM1, PM3, and PM5 Hamiltonians in CAChe Work System for Windows (ver. 6.01, FUJITSU, Inc.) was used in all of calculations (Ikuo et al., 2009) for optimization of geometry, for search of potential energies of various geometries of intermediates, for search of transition state, and search of the reaction path from the reactants to the products via the transition state. The optimized structure of the transition state was verified by the observation of a single absorption peak in the imaginary number by the use of the program Force in MOPAC (Stewart, 1989a, b, 1991) for vibration analysis. If the peak was observed, Intrinsic Reaction Coordinate (IRC) (Fukui, 1970) calculation was done and the reaction path was confirmed.

2.2 CG Teaching Material

A movie of the reaction path was produced by the software DIRECTOR (ver. 8.5.1J, Macromedia, Inc.) or Flash CS4 software (Adobe, Inc.) following the display of the bond order of the structure of the reactants in each reaction stage, which was drawn by the CAChe. It was confirmed that the Cast members were arranged on the stage and the molecular models of reactants moves smoothly. The ball was arranged on the reaction profile and the movement of the ball and the reactants was confirmed. The movie file was converted to the Quick Time movie by the Quick Time PRO (ver. 7.66, Apple, Inc.) and was saved to iPad (Apple, Inc.) by using the iTunes (ver. 10.7, Apple, Inc.).

2.3 Practice of Teaching Material

Teaching material was practiced to the first year students of teacher training course for elementary school and the second year students of natural environmental science course, of “Chemistry laboratory” at Tokyo Gakugei University. Teaching material used for the trial was the CG movie shown by the tablet computer.

3 RESULTS AND DISCUSSION

3.1 $I + H_2 \rightarrow Hi + H$

The CG teaching material of rearrangement by collision of diatomic molecule and one atom as shown in equation (1) was developed. PE of 2-D and 3-D is shown in figure 1. The figure clearly shows these changes of PEs with display on PE surface in 3-D, which offers a bird-eye view of the reaction profile. Two Valleys of lower energies and hilltop on the transition state at the saddle point can be recognized boldly. Possible pathways of the reaction from the reactants of I and H_2 to the products of HI and H *via* the transition state at saddle point can be readily traced. The CG teaching material is able to provide information about change of the PE and structure of reactants in a certain state simultaneously.

The electrostatic potential on electron density (EPED) model and ball-and-stick model of the intermediate, I-H-H, and the reaction profile were combined in the left side of figure 1 for easier recognition of those three. The electrostatic potential (Kahn et al., 1986) was calculated based on the coordinates of atoms from the IRC calculation (Fukui, 1970) and superimposed on to the iso-surface of the electron density at the value of 0.01 e $Å^{-3}$ as shown in the upper left part of the CG. The values of electrostatic potentials were represented in different colour on the model of intermediate. The model by EPED provides information about electrostatic distribution of the intermediate with realistic shape on the way of the reaction. In the middle of the CG, skeletal structure in the ball-and-stick model in which diameter of the stick reflects calculated bond order is shown. The lower left part of the CG shows the reaction profile, which demonstrates the degree of the reaction progress by the ball indicating the PE versus the reaction coordinate. Student could correlate this reaction profile with the reaction path in the right side of CG. The left side of the CG is able to provide information about characteristics of intermediate of molecule in a certain state on the progress of reaction.

From the posteriori survey, number of correct answers in question about “Energy” increased 28% compared with the preliminary survey (n=49). Students described their comments in the free description section of the questionnaire, such as,“With image, it was easier for me to understand the way of reaction and changes of energy.” and “I could see that reaction mechanism and energy change is closely related." These comments suggest that many students were able to obtain the concept of energy change in chemical reaction from the CG teaching material.

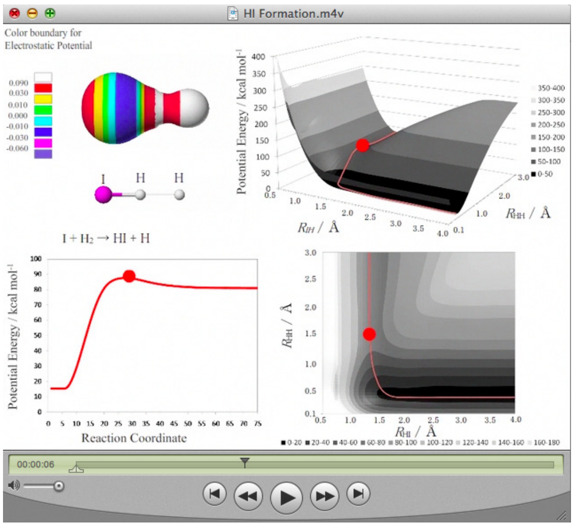
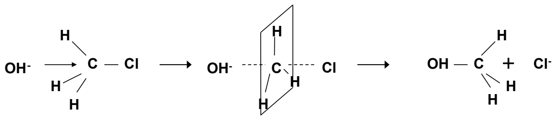


Figure 1: CG teaching material of I + H_2 → HI + H.

3.2 $OH^- + CH_3Cl \rightarrow CH_3OH + Cl^-$

Structural change of reactants in the reaction shown in equation (2) was studied as a model of Walden's inversion, which is also shown in scheme 1.

$$OH^- + CH_3Cl \rightarrow CH_3OH + Cl^- \qquad (2)$$



Scheme 1: Images of Walden's inversion.

Reaction of hydroxide and chloromethane is a typical example of the Nucleophilic Substitution in the 2nd order reaction. Carbon atom at the centre to which halogen attaches is attacked by the nucleophile, hydroxide, from a position 180 degrees from chlorine and then methyl alcohol forms. Therefore, the transition state was searched from the reactants where the bond angle of O-C-Cl was adjusted to 180°.

The inter-atomic distances of C-Cl in CH_3Cl was calculated as 1.87 Å (1.87 Å) (Weast, 1982), and C-O in CH_3OH was 1.41 Å (1.43 Å) (Shida, 1981). These values were in good agreement with the literature values in the parentheses. Energy between the initial state of reactants and the final state of products was 165.01 $kJmol^{-1}$. The value was in fairly good agreement with literature (Shida, 1981) value of 162.90 kJ mol^{-1}.

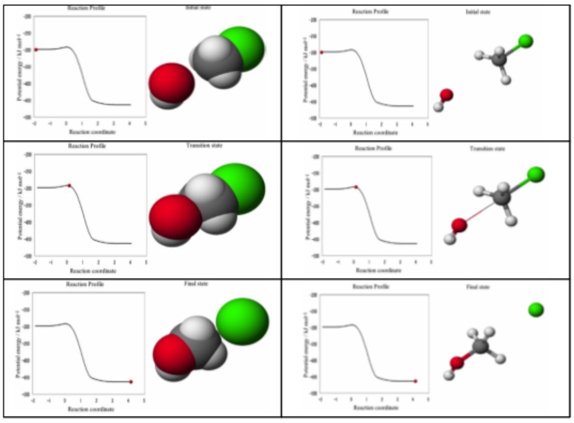


Figure 2: Selected picture of CG movies: from the CG teaching material; Reaction profile and image of reactants; in space filling and ball-and-stick model.

Selected picture of CG movies are shown in the figure 2. The CG shows the reaction profile, which demonstrates the degree of the reaction progress by the ball indicating the potential energy versus the reaction coordinate. Movies were made by using not only the space filling model which shows realistic shape but also the ball-and-stick model which shows change in molecular configuration easily. A student is expected to obtain the image of an umbrella reverse like motion in Walden's inversion. In the space filling, the existence probability of the electron is 90 %. In the ball-and-stick, the thickness of stick changes by bond order.

When the CG is touched by student, the Quick Time control bar appears and the red ball can move by student's choice. This manual control feature provides "Hands-on" feeling to student. This CG teaching material could provide not only images of energy change during reaction but also images of dynamical structure change during chemical reaction.

The CG teaching material could demonstrate the structural change of reactants with both space filling and ball-and-stick models along with the reaction profile, which can provide image of energy change during the reaction.

From the result of the questionnaires (n=103), the answer judged to be able to acquire the image of Walden's inversion (the image to which an umbrella reverses) was follows; the image obtained from the reaction formula was 24% and from the CG teaching material was 51%. The number of CG teaching material was better than that of the reaction formula. Students were abele to obtain the image of drastic change of the structure in Walden's inversion from the CG teaching material.

The CG teaching material can be loaded with note PC, tablet PC, and smart phone.

We tried to produce electric textbook for chemical laboratory (Figure 3), which integrates the observable level experiment and the molecular world.

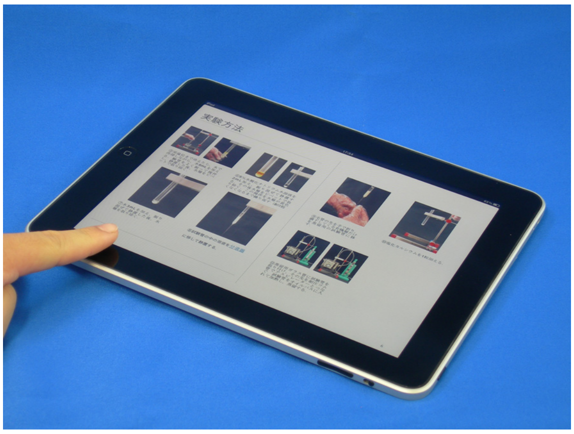


Figure 3: Prototype electronic textbook.

4 CONCLUSIONS

We produced CG teaching materials included 1) formation of di-atomic molecule such as hydrogen iodide, 2) hydroxylation of methyl chloride as a model of Walden's inversion. These teaching materials could demonstrate the nature of the reaction such as structural change by ball-and-stick model or space filling model with electrostatic potential, and potential energy change by the reaction profile. The CG teaching materials enabled to load with note PC, tablet PC, and smart phone. The CG teaching material of hydroxylation of methyl chloride was tried to combine with chemical experiments to make electronic textbook of basic chemistry.

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Tablets (iPad) for M-Learning in the Context of Social Constructivism to Institute an Effective Learning Environment

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Keywords: M-Learning, Tablets, Social Constructive Learning, iPad.

Abstract: With the proliferation of mobile devices, educational institutions have experimented with it to implement mobile learning (M-Learning). Studies have revealed that effective learning happens when teachers and learners are actively participating in the knowledge building process. Therefore, there is need for mobile applications that create effective learning environments which are learner-centred, knowledge-centred, assessment-centred and community-centred. Mobile applications used by educational institutes have been categorised and mapped to respective learning theories that it supports. From these it can be observed that none of the existing applications demonstrate social constructive perspective of learning theory.

1 INTRODUCTION

With the proliferation of mobile devices, educational institutions have experimented with various mobile devices to implement mobile learning (M-Learning). Mobile devices have been used to facilitate, support, and enhance and extend the reach of teaching and learning. But, use of mobile devices has not moved further than when it was first adopted. It is still used to provide and access mere information, rather than construct knowledge.

As M-Learning has been conceptualised with the assumption that learners are always on the move, M-Learning has been viewed as an isolated activity. To be able to view M-Learning as a rich, collaborative and conversational experience, we need good mobile applications. Mobile applications would act as a platform on which an effective learning environment can be created.

Tablets (iPad, Samsung Galaxy, etc.) have become pervasive technology because it is now widely embraced by students, teachers and even formally adopted by educational institutes. Its popularity can be credited to the availability of significant number of educational applications ranging from study aids to collaborative and interactive learning. Currently available educational applications have been categorised and mapped to learning theories that each app supports. Most of these applications support traditional learning activities instead of enhancing them.

Studies have revealed that effective learning happens when teachers and learners are actively participating in the knowledge building process. Therefore, there is need for applications that create effective learning environment.

2 M-LEARNING

M-Learning is defined as a form of learning accomplished with the use of mobile technology. Recently tablets have been added to the growing list of mobile devices used for teaching and learning purposes.

Educational Institutions have used mobile devices to demonstrate technological feasibility and pedagogical opportunity (Taylor and Evans, 2005). The US National Research Council produced a synthesis of research into educational effectiveness and they concluded that students learn effectively when the learning environment is learner-centred, knowledge-centred, assessment-centred and community-centred (National Research Council, 1999). These research findings match the social-constructivist approach of learning where students play an active role in a learning context and teachers and students collaborate to facilitate knowledge construction.

Therefore, as reported in EDUCAUSE report 2011, use of mobile devices are expected to change the didactic traditional classroom learning to a more active and engaging learning environment which also exploits the social-constructivist pedagogical approaches to learning.

2.1 Mobile Use in Higher Education

Zeng and Luyegu (2004) reported that the use of mobile technology resulted in escalated transformations, while in 2010 some researchers were still predicting that mobile technology could play an important role in the revolution of education (Liu and Hwang, 2010). This indicates that their use in education have not been evaluated and reported.

Mobile devices are largely being used for delivering information and barely being used to actively engage students in the learning process (Litchfield, Dyson, Lawrence, and Zmijewska, 2007, Rudd, 2011).

Mobile phones with their restricted screen size have limited their use to sending SMS (Short Messaging Service) messages, with prompts for course requirements, assignment due dates, polling answers for quizzes, and sending URL links to additional learning resources.

Tablet PCs have been used as an interactive digital whiteboard (Anderson et al. 2004; Willis and Miertschin 2004). They have also been used for note-taking, reading, and for in-class assessments, with the use of systems such as Lecturer's Assistant, and Class Presenter System.

3 TABLETS FOR EDUCATION

Tablets such as iPads have been designed and developed primarily as an interactive content consumption device with intuitive interface. Though the iPad was never specifically developed as an educational tool, educational institutions have widely started adopting iPads. Its advanced attributes allow the user to experience just-in-time learning opportunities, connection and convergence to other devices, networks and technologies. Thereby, users are not restricted to traditional limitations of time and space related to learning.

3.1 iPad for Teaching and Learning

Many universities worldwide have discussed and reported on the general uses of the iPad but none of the universities have determined a significant pedagogical use of the device in higher education. Additionally, the universities have not yet formally measured and reported the impact of the iPad.

Universities have adopted the iPad as a collaborative tool, a standardized mobile device to integrate into curriculum. Stanford University of Medical Science, Seton Hill University, University of Adelaide and several other universities around the world have started iPad projects. The core goals of these projects were to improve the student learning experience and also to replace traditional textbooks and other teaching materials with online study tools.

3.2 Impact of iPad in Education

The iPads have been effectively used as a content delivery device, complementing other forms of conventional content delivery methods. The University of Minnesota, Stanford University, and the University of California-Irvine are some of the medical schools that have handed iPads equipped with productivity, content delivery, and content consumption apps to students.

Therefore, reports released on these projects have limited its focus primarily on the use of the iPad as an eReader. Furthermore, Stanford University reported that its use did not significantly contribute to increased student learning outcomes. But these universities have left it to the students to explore the use of the iPad for learning, instead of integrating the device in the design of their teaching and learning activities.

4 TAXONOMY OF EDUCATIONAL APPS

Students and teachers have used numerous educational apps that are available on the Apple appstore (*www.**app**le.com/au/**ipad**/from-the-**app**-store/)* and some of the universities have even developed their own apps. The following taxonomy of educational applications has been developed to classify apps used for formal learning. In this context, formal learning is defined as learning where a university/department sets the goals and objectives of learning (Cofer, 2000).

These categories have been chosen after analyzing applications that are (or have been) used by the students and teachers in higher education. Each category is further described below.

i. Content Consumption and Creation Applications

ii. Content Delivery Applications
iii. Collaborative and Interactive Learning Applications
iv. Course Management Applications
v. Teaching and Learning Enhancement Applications

4.1 Content Consumption and Creation Applications

Students and teachers use these applications to read, take notes, concept map their ideas, create presentations, draw diagrams, and make use of spreadsheets to capture and analyse tabular data sets.

4.2 Content Delivery Applications

This category of applications is used to enhance the delivery of lectures and distribute podcasts of the lectures and discussions. These applications are used to make the lectures dynamic by using them as interactive digital whiteboard.

4.3 Collaborative and Interactive Learning Applications

Lecturers use this category of applications to encourage students to engage, participate, and provide them with platforms to collaborate and learn. It includes applications that encourage any kind of communication among teachers and students, including classroom polling applications, as they help in initiating classroom discussion.

4.4 Course Management Applications

Applications that universities use for administration purposes such as unit enrolment, class allocations, unit tracking, grade management, and to manage lecture and course content. Some of the universities have developed custom course management applications, while most universities use Blackboard Mobile™ application.

4.5 Teaching and Learning Enhancement Applications

These applications are used by teachers and students to support teaching and learning activities. . These applications also include file management applications that help people organise their files as the iPad does not have a file management system.

5 MOBILE APPLICATIONS AND LEARNING THEORIES

In the following table, the above categories are compared with the classification of mobile learning activities developed by Naismith et al. (2004).These authors have categorized activities around existing relevant learning theories.

Table 1: Application taxonomy with relevant learning theories.

Mobile Application Category	Example Mobile Applications	Learning Theory
Content Consumption and Creation	Consumption: inkling, GoodReader, Creation: EverNote, AutoCAD WS	Some apps have quizzes which partially support Behaviorist learning theory
Content Delivery	KeyNote, Podcasts,	Constructivist learning theory
Collaborative and Interactive Learning	Edmodo, iClicker, iResponse Convore, tweet	Behaviorist learning theory Collaborative Learning
Course Management	Blackboard Mobile™ and university applications	Not Applicable
Teaching and Learning Enhancement	Splashtop, Air Sharing, DropBox	Not Applicable

The iPad projects have reported that its use did alter academic workflows, such as making them paperless, web resources were easily accessible, easier note handling, marking made portable, and listen to podcasts anytime (Marmarelli, 2011, Hardy and Suter, 2011, Murray and Olcese, 2011).

Available educational applications demonstrate that the iPads have just been used to replace traditional modes of teaching and learning. They have indeed made learning and teaching efficient, but there are no formal reports on being able to create effective learning environments.

Therefore, universities need to develop applications that help create learning environment that supports the social-constructivist approach to learning, where students play an active role in their learning, and teachers and students collaborate to facilitate knowledge construction.

6 CONCLUSIONS

Educational institutions have experimented with almost every available mobile device, to enhance and to make learning more effective. The tablet is the latest technology that universities have started adopting. The availability of numerous educational applications for the tablet gives it an edge over all the other mobile devices.

From the taxonomy presented above, it can be seen that all of these educational applications demonstrate behaviourist, constructivist and collaborative perspectives of the learning theory and none of them demonstrate the social constructivist perspective of learning theory

There are very few applications that provide interactive and collaborative pedagogy. To make tablet an effective educational, there is need for educational applications that can capitalize on the benefits of effective learning pedagogies.

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Understanding Pervasive Games for Purposes of Learning

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Keywords: Game Based Learning, Serious Games, Pervasive Games, Storyboarding.

Abstract: Among the manifold of approaches to technology enhanced learning, game based learning is very attractive. In game based learning, the technological systems employed for the purpose of learning are digital games. Stand-alone serious games are rare. Games deployed for learning need to be embedded into suitable contexts. A particular approach promising from certain didactic perspectives and driven by a variety of characteristics of learning contents and training requirements is embedding those games into the surrounding physical world. Games embedded into the physical world are called pervasive games. The ways of embedding are paramount. There have been numerous attempts to design and to implement pervasive games, in general, and to deploy pervasive games for learning purposes, in particular. The majority of those pervasive games failed quite badly. Storyboarding the interaction between the real world and the virtual world of a pervasive game reveals the essential strengths and weaknesses of the game concept and allows for diagnosing didactic flaws of game play. Beyond its diagnostic power, the approach supports the design of more affective and effective pervasive games. Storyboarding is a methodology of anticipating human experience and, thus, a methodology of didactic design.

1 THE AUTHORS' POSITION

All of us–readers and authors of this manuscript–are aware of the fact that so-called digital natives[1] have other expectations when facing digital media than their parents and teachers. Playful learning, whenever possible, and using digital games for learning without any fear belongs to the widespread expectations teachers and trainers have to fulfill.

In response, game based learning and serious games are terms naming some prosperous field of technology enhanced learning.

When the learning contents is out there in the surrounding world, it seems plausible to bring the games out there as well–pervasive games concepts evolve.

In harsh contrast to the promises, most pervasive games failed badly.

There will surely be no superficial and short explanation for a large number of finally disappointing game developments. But understanding the past and shaping the future surely needs some pondering, some exchange of opinions, and several innovative ideas. The authors aim at some small contribution to this process by advocating their position,

- ○ that there are decisive characteristics of pervasive games which may be well explicated by suitable approaches of storyboarding applied to pervasive games.

Using storyboarding a posteriori, it turns out to work as a diagnostic tool. Doing it a priori, storyboarding becomes a tool for design and development fostering to draw conclusions from lessons learned in earlier projects that failed.

Based on the authors' key position above, one is lead to some more viewpoints worth to be considered.

- ○ Pervasive games may be classified according to their pervasiveness which is of didactic relevance.
- ○ The crucial embedding of learning contents into game play may be characterized quite well by means of storyboarding terminology.
- ○ The storyboarding technology, by its very nature, allows for an explication of the context conditions in which learning is likely to take place.

The basic terminology will be introduced briefly to be applied to a larger number of pervasive games.

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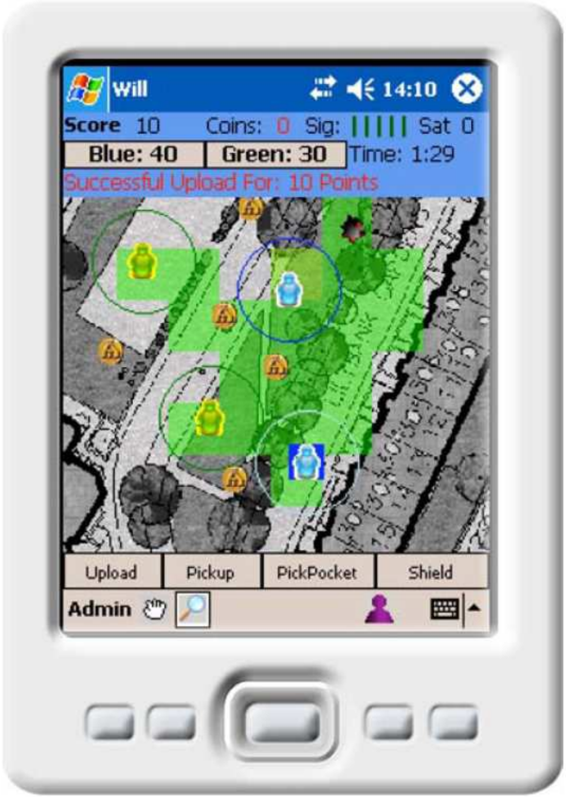
[1] The term *digital natives* as polemically opposed to denigratingly called *digital immigrants* is, exactly in this sense, ascribed to Marc Prensky (Prensky 2001), although the idea as a whole dates back to (Barlow, 1996) writing: "You are terrified of your own children, since they are natives in a world where you will always be immigrants."

2 INTRODUCTORY CASE STUDY

Before going into the details of discussion, the authors are aiming at an intuitive introduction. Instead of presenting notations in a formal way, a certain digital game is used to exemplify what the present paper is about, which concepts are in use, and how typical problems are formulated and attacked.

The game selected for an introduction by example is TREASURE (Chalmers et al., 2005) which is one of the earliest pervasive games. The purpose of the game TREASURE is to *learn* about wireless communication. The ideas underlying this game are easy in structure.



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Blue: 40 Green: 30 Time: 1:29

Successful Upload For: 10 Points

Figure 1: Interface to the TREASURE game as it appears in some PDA; picture taken from (Chalmers et al., 2005) with the permission of the authors as it appears in (Jantke, 2006).

Some real urban environment such as a park, e.g., is virtually equipped with virtual treasures[2]. Teams of players are running around in pursuit of treasures. Team members in the real world are localized by means of GPS technology relating them to the virtual treasures and to each other. In certain areas, there are WLAN connections allowing players to contact their virtual treasure boxes on the server for upload.

(Chalmers et al., 2005) describe variations of the game mechanics. The core idea, however, is lucid. The storyboard in fig. 2 is summarizing the essentials.

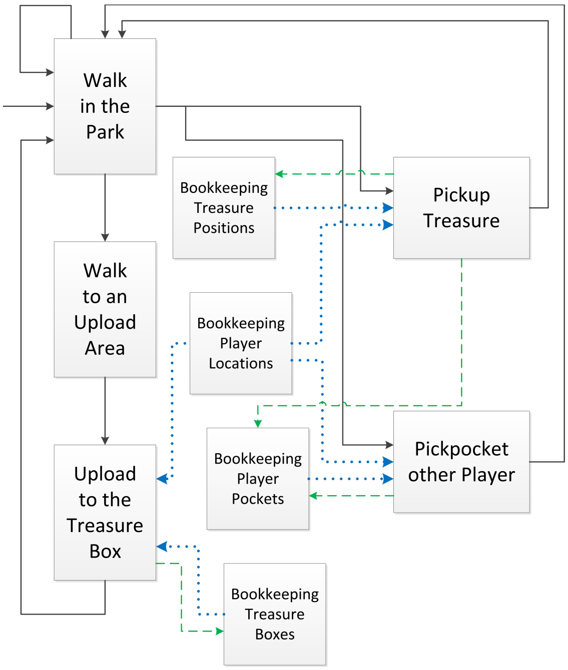

Figure 2: Storyboard of TREASURE's game mechanics.

Every node is an episode or a scene describing some action. Smaller inscriptions describe actions of the computer system as opposed to actions of human players. Solid lines indicate the passing of a human player from one action to another such as, for illustration, from just walking to picking up some treasure. Dashed green lines indicate that the player's action causes some actions of the computer system. In turn, dotted blue lines indicate the impact of earlier game actions on the player's current actions. For instance, virtual treasures can only be discovered and picked up where the computer system has placed them virtually. Arrows indicating update operations of the players' positions have been dropped.

Game playing means moving around, collecting virtual treasures, trying to pickpocket each other, and aiming at uploads of the own virtual treasure to the safe virtual treasure box. The bookkeeping of treasure locations and treasure boxes defines the termination of game play.

The simplicity of the storyboard above reflects the simple structure of the underlying game concept.

Furthermore, it exhibits that there are no actions of interest performed by the game system except bookkeeping and, thus, determining preconditions of player actions. The game system is not perceived as an actor, but more seen as a supervising game master.

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[2] For the borderline between reality and virtuality, in general, and for its relevance to e-learning, in particular, interested readers are directed to (Jantke and Lengyel, 2012).

3 STORYBOARDING GAMES

This paper uses storyboarding as a technology, but does not aim at anything such as an introductory course to storyboarding. The authors rely on the basics as introduced by (Jantke and Knauf, 2005) and confine themselves to those notions and notations needed for the purpose of characterizing pervasive games. Recent work on storyboarduing digital games such as (Jantke and Knauf, 2012), e.g., is worth some comparison.

Storyboards are hierarchically structured graphs. The composite nodes are named episodes, whereas the atomic nodes are named scenes. Composite nodes may be subject to substitution by some other graphs. In contrast, atomic nodes have some semantics in the underlying domain. They may represent documents such as videos, pictures, or text files in formats like pdf, e.g., but they may also represent some activities of human learners, co-learners, teacher, tutors, or those actions performed by certain digital systems.

The usage of composite nodes in a graph allows for the representation of anticipated experiences on different levels of granularity (see (Lenerz, 2009)).

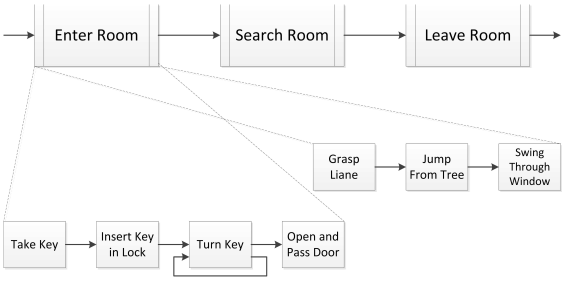

Figure 3: Cutout of some storyboard with three episodes.

Just for illustration, fig. 3 above is showing two alternative substitutions for an episode. The graphs for substitution on display contain only scenes which have a particular operational semantics. In general, subgraphs may also contain episodes.

Graphs may contain branches and loops, where there are different branches for indicating alternatives, multiple choices, parallelism of action, and the like.

Every storyboard specifies a usually rather large number of paths through the storyboard describing, for instance, varying experiences of game playing or different ways of learning.

The art of storyboarding is to anticipate and to specify the manifold of forthcoming actions including human-computer interaction, human-to-human communication and individual activities like pondering particular problems or reflecting own achievements. Seen from an e-learning perspective, storyboarding means technology enhanced didactic design.

4 PERVASIVE GAMES VS. SERIOUS GAMES

Game based learning is an established paradigm of technology enhanced learning (see, for instance, (Prensky, 2001), (Ritterfeld et al., 2009)), although it does not yet play any remarkable role in conference series such as CSEDU.

Contemporary taxonomies and classifications of serious games such as (Sawyer and Smith, 2008) and (Ratan and Ritterfeld, 2009) do not even mention the term pervasive game or the game property of being pervasive.

This particularly unsatisfactory state of the art bears abundant evidence of the need for pondering the peculiarities of those serious games that fall into the category of pervasive games as well.

No doubt, there are serious games which are not pervasive and there are pervasive games which do not deserve to be called serious. This paper's focus is on the intersection of the two categories, exclusively.

A game may be called pervasive if the experience of playing is based on a certain mixing of real world elements and virtual elements. Crucial to the human experience is the interplay between the real world and the virtual layer. Virtual actions may be the trigger for physical actions in the real world and vice versa.

Playing some pervasive game is characterized by

- face-to-face communication and social interactions among players,
- physical interactions between human players,
- physical activities in real environments,
- the dynamics of reality influencing game play,
- virtual world components expanding the reality.

The virtual game world may give new meanings to parts of the real world. For instance, some road may be seen as a river and some building becomes a castle. Beyond the limitations of conventional digital games, actions in the game world may have real-world preconditions and may require real-world actions.

According to constructivist approaches to learning (Thissen, 1997), human learners acquire knowledge in an active process which may be highly iterative. In dependence on the general domain and the specific subject of learning, experimentation, trial and error, haptic experience and the like may be crucial. In game-based learning, pervasive games are those bridging the gap to real experiences in the real world.

Even rather simple approaches to playing pervasive games for purposes of learning–compared to classroom approaches–may lead to some higher energetic activation, more positive emotions and attitudes towards learning activities (Kittl et al., 2009).

5 UNDERSTANDING GAMES BY MEANS OF STORYBOARDING

Storyboarding is not only some technology of a priori design, but also some means of a posteriori analysis and understanding. Storyboarding bears the potential of explicating an interactive system's characteristics which are decisive of the impact of interaction.

Some earlier papers in the area of pervasive games contain diagrammatic representations looking like storyboards (see (Markovic et al., 2007), fig. 5, e.g.), but the visualizations do not yet sufficiently well both separate and relate the two game world components.

5.1 Classifying Pervasiveness of Games

Roughly speaking, storyboards of pervasive games explicate three related, but different aspects of each game: what happens in the real world, what happens in the virtual world, and how the two parallel worlds communicate with each other.

INSECTOPIA (Peitz et al., 2007) is the name of an interesting, but not too complex pervasive game using bluetooth technology as the means to connect the real and the virtual world.

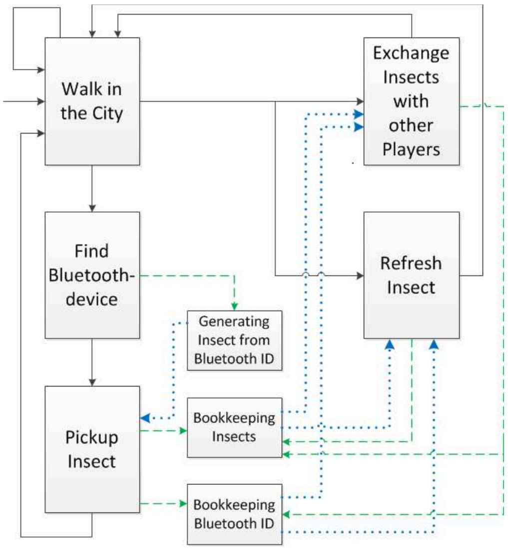

Figure 4: Essentials of the INSECTOPIA game play.

Humans playing INSECTOPIA walk around to collect virtual insects in the real world. Via the Bluetooth interface of his internet connected smartphone, INSECTOPIA is constantly looking for other enabled Bluetooth connections within range. When the human player, intentionally or just by chance, is getting into the reach of some other activated Bluetooth device, INSECTOPIA uses whose Bluetooth-ID to generate a virtual insect on the players smartphone.

Metaphorically speaking, pervasive games are like board games, in which the real world serves as the board, the human players are the pieces moved around, and the computer technology implements the game mechanics. For a particular pervasive game,

1. it may be freely played anywhere,
2. it may be played where virtual objects are set up,
3. it may be definitely bound to some fixed location.

INSECTOPIA is of the first and TREASURE is of the second type as can be deduced from the *Bookkeeping Treasures Node*. What follows is a third type example.

In January 2007, it was proudly announced that the German city of Regensburg, a beautiful place, gets *the first permanent high-tech city game of the world* (see (Borchers, 2007), first sentence of the article). Launched in May 2007, the tracks of the game on the Internet vanish already in Summer of the same year–not really a *permanent* success.

(Ballagas and Walz, 2007) allow for some deeper insights into the game's characteristics.

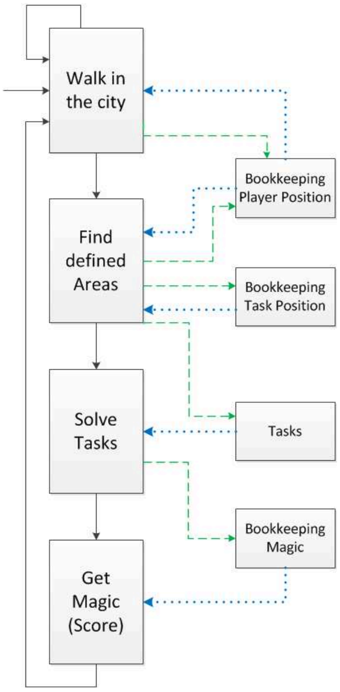

Figure 5: Essentials of the REXPLORER game play.

REXPLORER offers the possibility to explore the history of the German city of Regensburg in a playful manner. In this game, the player is guided by GPS to certain points of interest in the city. At these points, historical knowledge is imparted to the player through story-driven multimedia learning content.

5.2 Storyboarding Issues of Learning

The introductory game case study of TREASURE (see figs. 1 and 2) describes a pervasive game developed and implemented with some specific learning goals in mind: learning about wireless communication with emphasis on the seams in communication networks. When playing the game, human players are acting in the real world aiming at experiencing scenes such as "Pickup Treasure", "Pickpocket other Player", and "Upload to the Treasure Box" (see fig. 2 for details). They are only learning by becoming aware of the system-executed communication activities indicated by the dashed green lines and by the dotted blue lines, respectively, in fig. 2.

So, the storyboard does clearly indicate what is relevant to this pervasive game's educational impact. This may be used, for instance, in designing assessment strategies.

This section aims at the presentation of another case study published, among others, in (Winter and Pemberton, 2010) and (Winter and Pemberton, 2012).

According to (Winter and Pemberton, 2010), INVISIBLE BUILDINGS is a cross-curricular whole-day learning experience integrating outdoor mobile location-based games with complementary indoor classroom-based activities addressing primary school children aged 9-10 years.

The game is played by means of GPS-enabled smartphones. These smartphones are attached to custom-made mock-up tools simulating, for instance, metal detectors. The metal objects found in the school ground are put there very much like the treasures of the TREASURE game are hidden in the park (fig. 1). Other mock-up tools allow for the discovery of virtual building structures underneath or may be used for digging virtually.

The whole learning activity is composed of indoor and outdoor episodes as shown in fig. 6 (see fig. 1 of (Winter and Pemberton, 2010), for comparison).

Publications such as (Winter and Pemberton, 2010) and (Winter and Pemberton, 2012), unfortunately, do not provide sufficient detail for a reliable expansion of the storyboard shown in fig. 6. Therefore, the authors confine themselves to an in-depth discussion of just one part of the game play under consideration.

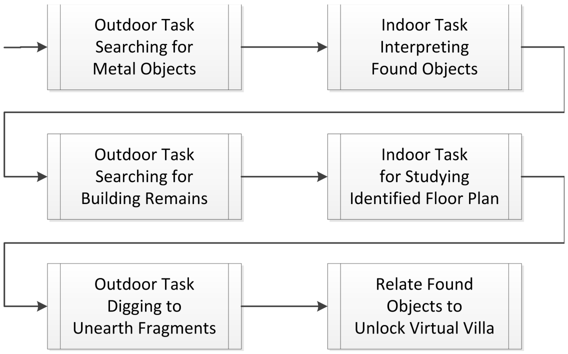

Figure 6: Top level storyboard of INVISIBLE BUILDINGS.

The particular episode shown in figure 6 entitled *Outdoor Task Searching for Building Remains* expands as shown in fig. 7 below.

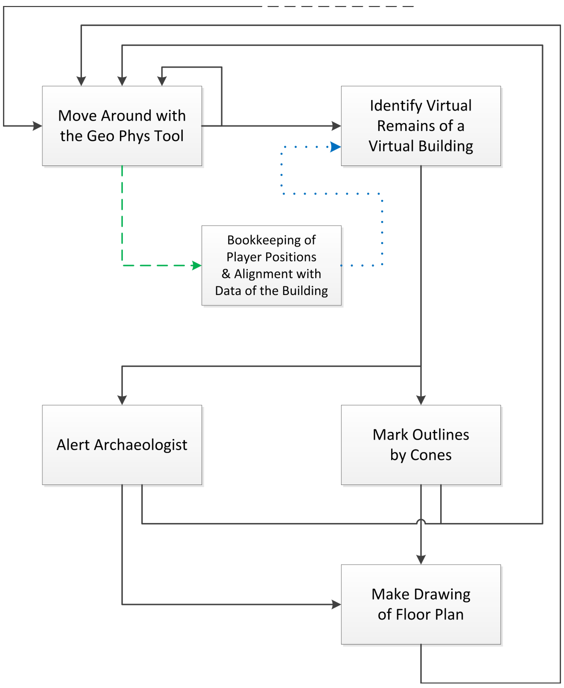

Figure 7: INVISIBLE BUILDINGS storyboard expansion.

The episode expanded in fig. 7 is entered by walking around with the virtual Geo Phys tool. It may be left at any scene on display to continue by playing the next indoor episode.

The game system's tracing of player positions does possibly trigger the scene of discovering some virtual building remains. Subsequently, players have both to alert the archaeologist and to mark the newly found positions of the remains.

When playing this episode is completed, the floor plan drawn by the players is carried over to the next indoor episode in which the players' floor plan is further investigated and interpreted.

The storyboard above reveals that in the game INVISIBLE BUILDINGS the game system does not perform substantially more interesting activities than in the other pervasive games investigated before. But it definitely encourages a larger variety of human learning activities.

The INVISIBLE BUILDINGS pervasive game has some peculiarities which make it unlikely to be played frequently[3]. As reported in (Winter and Pemberton, 2010), section 3.3, an enormous amount of staff is required to play the game. Adults such as teachers and parents all "played a role in the project and a professional actor was introduced to play the part of an Indiana Jones-style archaeologist".

6 CONCLUSIONS

Storyboarding is a methodology of didactic interaction and media design. A posteriori storyboarding of pervasive games helps to understand decisive characteristics and deficiencies of those games. Due to the peculiarities of triggering real life activities, pervasive games are forming a particularly promising category of serious games. As a methodology of instructional design, a priori storyboarding becomes crucial.

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[3] There are extreme cases such as the pervasive game EPIDEMIC MENACE which, according to (Lindt et al., 2007), has been played exactly twice (ibid., p. 3, section 3).

Utilizing Umbrello UML Modeller to Develop Students' Modelling Skills in Software Engineering

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Keywords: UML Umberllo, Teaching Software Engineering, Modelling Techniques.

Abstract: This paper looks at the introduction of UML Umberllo in a university-level course to assist learning software engineering. In theory, Umberllo should help students better visualize the design of models in a pragmatic and clearly-defined way, which in turn should be reflected in students' outcome. We identify lack of experience as a major constraining factor with negative implications in students' models. Initial results are encouraging and show that students are willing to embrace the new method and that Umberllo itself can help deliver more comprehensive and coherent designs.

1 INTRODUCTION

Experts in software engineering point out that teaching its various techniques successfully and effectively while maintaining the relation to the practical aspects can be a very demanding task, one which is further compounded by students' lack of experience at both industrial and developmental levels as Mingins et al., (1999) and Meyer (2001) believe. Some challenges originate from the conceptual themes involved (e.g. modeling) rather than the practical activities as compared to programming languages courses where the language is taught using IDEs according to Baar (2012) and Moisan and Rigault (2010). Students usually have very limited or even no industrial experience which according to Mingins et al., (1999) further complicates teaching and learning. This partially explains why certain concepts in software engineering can eventually fall into fallacy among people who study them.

This paper reports on our attempt to address these issues when teaching software engineering by utilizing UML Umbrello. We have utilized the tool as a free UML modeller to teach system modelling topics of software engineering.

The new module is split into two general themes, a theoretical theme in which students are taught the modelling languages using Umberello and a more practical theme in which students are given the opportunity to practice building models for their respective group projects.

The paper starts by introducing the concepts of system modelling in software engineering in general and UML modeller in more details. It then describes the approach we followed when teaching software engineering using the modeller. The reflections of the experience should establish our own account for the new teaching method, what positive gains were reported as well as challenges experienced in the implementation stage.

As this work is in progress, the main focus will be on building a theoretical foundation upon which success of future projects can be judged in relation to the outcomes of the current project. We essentially have established the theoretical framework but we still are looking for is the concrete evidence to support implementing our alternative teaching method.

2 UMBRELLO UML MODELER

Umbrello UML Modeler is an open source software tool developed by computing students (including Riddell, 2008) to function in several platforms of operation systems (e.g. Unix-like and Microsoft Windows). The tool allows the user to deal with the standard UML diagrams required during the analysis and design phase of the software development process. The user has the option to start from scratch, export, and/or reverse engineer the codes or diagrams from many other supported software like C++, Java, PHP, SQL, JavaScript, and XML. Documentation is a vital part of software design, especially for medium and large scale projects, accordingly, Umbrello provides their user the option to document the development and design process in order to support future stages of developments.

3 SYSTEM MODELING IN SOFTWARE ENGINEERING

Sommerville (2004) identifies four major types of modelling techniques in software engineering namely, structural, behavioural, contextual, and interaction modelling for software systems. The focus in this article is on the first technique, structural. The structural modelling requires developing various diagrams, most notably 'class' and 'entity-relations' diagrams. The experimentation we conducted for evaluating the applicability of Umbrella however exclusively investigates the 'class' diagram modelling.

According to Martin (1997), the class diagram is an abstract representation of the real classes implemented in object-oriented programming languages such as Java. It defines the architecture of an application in terms of its composing classes and the different types of relationships between the classes. The tool can also represent packages involved in the system that constitute functional classes. Figure 1 below illustrates an overall view of class diagram representation modeled using Umbrello.

Figure 1: Class diagram representation in Umbrello.

One of the key challenges as reported by students is understanding the types of relationships between classes. Umbrello fits perfectly here as it demonstrates the different relationships using specific symbols to represent the semantic of each type. The table below summarizes the different relationships in class diagram modelling and their corresponding representation in Umbrello.

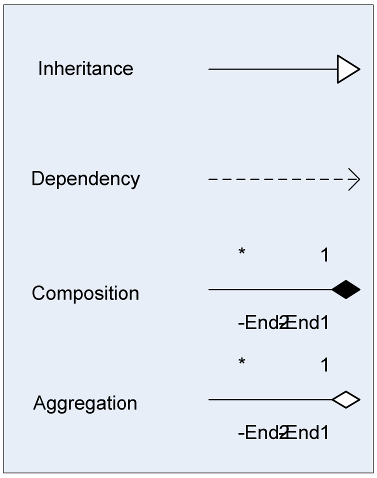

Figure 2: Class diagram relationships.

4 METHODOLOGY

The main researcher taught software engineering courses to two different groups of students over two semesters. A total of forty-eight students were included all in the third year of their computer science programme. They should have a relatively good programming background as a result. The first group acting as control group was taught using traditional teaching methods including sessions in UML and group projects. They were allowed to use a variety of modelling techniques ranging from Visio to simple hand drawing. The other group, experimental, was taught how to build their models using Umberllo. Members of this group were required to use it in developing their projects and systems.

Three main criteria were developed to evaluate the two approaches; learnability, mastery and compliance with standards. The first two were weighted at 15% towards the final mark each and compliance weighted at 70%.

Data was collected using a number of tools including regular quizzes, classroom participations, exams and group project reports.

5 RESULTS AND DISCUSSION

As far as learnability is concerned, both groups expressed their interest in learning more UML modelling techniques. In fact, no significant differences can be found here. The second criterion however, mastering the application, has resulted in more diverse students' projects. The control group failed to implement the learned knowledge in their projects. Confusion over different classes was evident. Furthermore, the definition of classes in class diagram was largely inaccurate. The experiment group on the other hand produced more complex and professional models. The visual representation of relationships helped students design their models accordingly. Finally, as compliance with standards was concerned, members of the control group occasionally resorted to ad-hoc designs ignoring accurate representation of relationships. As a result, their code structure was disorganised. The other group on the contrary produced more organised models. Umberllo generated the required code structure accompanied by the defined relationships. Students' workload has been greatly reduced to writing the functionality in the body of the code.

Umberllo therefore lived up to our expectations. Students appreciated the visual representation of their models and the fact that such a method helped foster the overall organization of their respective projects.

As this is an early stage of the execution, the immediate impact of the tool cannot be conclusively and accurately measured. If we assume that other factors (students' grades, level, ages, previous knowledge and experience) are contributing equally to the final results in both occasions, the addition of Umberllo would undeniably be a positive one.

6 CONCLUSIONS AND FUTURE WORK

This project is unequivocally a work in progress, yet it shows great promise in consolidating students' perception of newly designed models. In fact, the whole experience turned to be engaging and informative. Some general teething issues were expected prior to Umberllo implementation including the inevitable issues of training students to use the tool and carrying out follow-up exercises, both of which are time-consuming.

Despite that, students taught using Umberllo produced better organised class diagrams. They were also more capable of explaining the different types of relationships. These are two very important qualities that were missing from the students taught using traditional methods. Not only did Umberllo facilitate the organisation of students' projects, it also had considerably reduced the amount of work needed in building code structures. This effectively means that students can focus on writing the functionality without having to spend extended periods of time defining the relationships of classes.

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WORKING SESSION ON CLOUD EDUCATION ENVIRONMENTS

FULL PAPERS

Cloud-based Learning Environments: Investigating Learning Activities Experiences from Motivation, Usability and Emotional Perspective

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Keywords: Cloud-based Learning Environments, Cloud-based Tools, e-Learning, Evaluation, Usability, Accessibility.

Abstract: Cloud education environments consider all the cloud services, such as Web 2.0 applications, content, or infrastructure services. These services form an e-learning ecosystem which can be built upon the learning objectives and the preferences of the learner group. A great variety of existing cloud services might be re-purposed for educational activities and it can be taken advantage from already widely used services without steep learning curves on their adoption. In this article is presented the design, deployment and evaluation of learning activities using cloud applications and services. The experiences presented here are from Galileo University in Guatemala with students from three different countries in Central America and Spain. This study reports findings from motivational attitudes, emotional aspects and usability perception. Selected cloud-based tools were used for the different learning activities in three courses in various application domains. These activities include collaboration, knowledge representation, storytelling activities and social networking. Experimentation results obtained aim to demonstrate that students are eager to use and have new and more interactive ways of learning, which challenges their creativity and group organization skills, while professors have a growing interest on using new tools and resources that are easy to use, mix and reuse. Thus, future research should focus on incentives for motivating participation as well as on providing systems with high usability, accessibility and interoperability that are capable of doing learning orchestration.

1 INTRODUCTION

Trends for modern Virtual Learning Environments (VLE) indicate a movement from a monolithic paradigm to a distributed paradigm. Dagger et. al. (2007) and Chao-Chunk and Skwu-Ching (2011) call it the next generation of e-Learning environments. It is clear that Virtual Learning Environments need to be more scalable and improve the real innovation they bring to education through flexibility, due the increasing requirements that higher institutions have. Actual work in Cloud Computing has a focus on infrastructure layer rather than application layer as shown in the work of Al-Zoube et. al. (2010) and Chandran and Kempegowda (2010). Still VLE is in many cases a simple conversion of classroom-based content to an electronic format, retaining its traditional knowledge-centric structure as stated by Teo et. al. (2006).

There is great potential in the use of multiple cloud-based tools for learning activities and to create a different learning environment, with new diversity of tools driving to possibly enrich learning experiences. There is a quest to create a Cloud Education Environment, where a vast amount of possible tools and services can be used, connected and in the future orchestrated for learning and teaching (Mikroyannidis, 2012).

Cloud computing application technologies are a major technological trend that is shifting business models and application paradigms; the cloud can provide on-demand services through applications served over the Internet for multiple set of devices in a dynamic and very scalable environment (Sedayao, 2008). Thus, the significance of the technology for this study lies not only in cloud computing, but in the application that reside in the cloud that can be used for learning purposes, although as it will be presented, many of them have not been intended for learning in the first place, the applications presented in this experience are actually used for learning. Cloud-based tools have the potential to interoperate with other systems; therefore it is possible to systematically orchestrate a learning activity through multiple cloud-based tools. The cloud-based tools are normally seen as traditional and standalone web 2.0 tools, but now it can create integrated learning experiences. This paper does not focus on the cloud-computing infrastructure but rather on the findings of using the existing cloud-based tools for learning. Likewise social networking technologies provide easy pathways for sharing these kinds of cloud applications, related data, activities and for socializing while at the same time enhancing the collaborative experiences (Mazman and Kocak, 2010).

This paper is organized as follows: first we will describe the test-beds used for this experience, the learning activities designed and the learning scenarios. Thereafter we will give a detailed description of the instruments used, the methodology description and results of our study, in which students were asked to perform learning activities individually and in groups using different type of Cloud-based tools. Finally we will discuss our findings, conclusions and some ideas of future research.

2 THE EXPERIMENT

2.1 The Galileo University Test-bed

In this section we present a cloud-based learning experience in Latin-American countries following other successful learning experiences by Dagger et al. (2007) and Chao-Chunk and Skwu-Ching (2011). The learning experience happens in the Institute Von Neumann (IVN) of Galileo University, Guatemala. IVN is an online higher education institute. It delivers online educational programs across the country and those programs are open for other countries.

The student population at IVN is mostly part-time students; this is something quite common in the entire University students. The courses are similar to any other University course; most of the students do their learning during the evening or in weekends because of work.

It is a complete online learning degree, the topic of the course is an e-Learning certification that consists in several modules that specializes the students into e-Learning from an instructional design reference. The course does not have formal synchronous sessions, although the use of chat with professor and other peers is possible. Also the students are expected to work 10 hours/week on their studies, learning activities and collaborative activities. The courses within the e-Learning certification are designed in learning units that usually last for 1 week each unit having a diversity of online material such as video, audio, animations, interactive content, forums, assignments and a wide diversity of learning activities specially designed for enhancing learning acquisition. The course uses the institutional LMS that currently is .LRN LMS (www.dotlrn.org), although some module are alternative provided in Moodle LMS (www.moodle.org). The students have the advice and help from professional instructional designers to build their online course. The Certification is targeted to university professors, e-Learning consultants, instructors that want to enhance their knowledge about teaching with technology.

The presented learning experience has two groups of more than 60 students, most of them university professors, from different countries: Guatemala, Honduras, El Salvador and Spain. The courses titles are: course 2: Introduction to e-Learning; course 3: e-Moderation and course 4: Online activities design.

The first group (A) with 36 students from Guatemala and Spain was evaluated with activities prepared within courses 2 and 3. The second group (B) with 30 students with students from universities in Guatemala, Honduras and El Salvador was evaluated with activities prepared within courses 3 and 4, thus the course 3: “e-Moderation” as common course for all groups is used for comparative analysis.

In this experience, students were assigned to cloud-based learning activities for the first time, most of them were not very familiar with related technologies, but they had a preliminary course that introduced them into the use of the institutional LMS and related technologies.

The course professor introduced the cloud-based learning activities as *innovative and powerful tools for learning*, with the objective to elaborate all the benefits that can create mind-set change, guiding the students through the benefits that these type of activities will have in their learning process (Chao-Chun and Shwu-Ching 2011), something that proved to be very helpful to avoid resistance and possible fear to new and seen as complex tools. We collected information form students in a pre-test and post-test through an online survey from an exploratory approach. Each group did two four-week courses, between the courses there was a one-week off that we used to do telephone interviews and gather further information about the experience.

2.2 Learning Activities and Scenarios

We designed learning activities based on instructional objectives, using as a base the past standard non-cloud-based activities from previous editions of the courses, and transforming them to leverage the potential of the cloud ecosystem. The designed and tested activities are presented, it is important to mention that each activity was carefully designed using a custom made instructional design template that contains all activity related information such as: learning objectives, instructions, classification using Bloom's revised taxonomy (Anderson and Krathwohl 2001) and grading. Each single step on the activity has a clear and explicit grading. With a clear design of the activity, the professor and instructional designer proceed to select the most suitable tool based on previous knowledge and experience with the tool, in the presented experience most of the proposed tool has been already used for other learning activities in other courses, the three courses were:

Course 2 "*Introduction to e-Learning*", had the following learning activities:

- *Activity 2.1*: Students had to do a research of a given topic, and then write collaboratively an essay in groups of four students each. This activity was prepared with a control group setting for comparison, where we divided the whole group (A) of students in three segments with nine groups (three groups per segment), first two segments using cloud-based learning activities and the third one using traditional desktop applications. The first two segments were asked to use cloud services: Google Docs (Google Docs-Page 2012) and Wiki Spaces (Wiki Spaces-Page 2012) and the other segment of three groups used traditional word processor. Then students were invited to represent the information with a time-line tool, the cloud-based time-line tools used were Dipity (Dipity-Page 2012) and Timetoast (Figure 2) (Timetoast-Page 2012) and the traditional tool was Power Point for segment three. Finally students had to comment and discuss other groups' results in the LMS online discussion forums. A summary of the tools used by groups are presented in Table 1.
- *Activity 2.2*: Students (individually) had to do a research and present knowledge gained through mind map tools, the cloud application for this activity was MindMeister (MindMeister-Page 2012) and Cacoo (Cacoo-Page 2012) (Figure 2). Finally they were invited to discuss about other peer contributions on the LMS discussion forum. A comparison setting is presented in Table 2.

Table 1: Comparison setting for Activity 2.1.

Segment	Tools used for the learning activity
1 (3 groups)	Google Docs and Dipity
2 (3 groups)	Wiki Spaces and Timetoast
3 (3 groups)	Word Processor and PowerPoint

Table 2: Comparison setting for Activity 2.2.

No. of Students	Tools used for the learning activity
10	Cacoo
10	Mindmeister
16	PowerPoint

Figure 1: Screenshot of Timetoast time-line example.

Figure 2: Screenshot of Cacoo mind map example.

Course 3: "*e-Moderation*", had the following activities:

- *Activity 3.1*: Students had to synthesize information learned in the course and publish it using the cloud-tool Issuu (Issuu-Page 2012). Then discuss on LMS forums.
- *Activity 3.2*: Students had to do a research, create a storytelling script and present it using one of the following cloud-based tools: GoAnimate (GoAnimate-Page 2012) (Figure 3), Xtranormal (Xtranormal-Page 2012), Pixton (Pixton-Page 2012). Publish it in the social network Facebook and comment other peers' contributions.

Course 4: "*Online activities design*", had the following learning activities:

- *Activity 4.1*: the group (B) of students had to build collaboratively bookmarks based on a research assignment using a base taxonomy provided by the professor to classify the links provided by the students. The Delicious bookmarking site (Delicious-Page 2012) was used for the activity.
- *Activity 4.2*: Students had to create online satisfaction survey for courses, synthesize a method and requirements for these types of surveys using a mind-mapping tool and publish a sample survey using Google forms (Google Docs-Page 2012).
- *Activity 4.3*: The learning activity focused on modelling a process for creating visually attractive digital posters with educational intentions, first by using a mind-mapping to elaborate the concepts, and then reflect them in an cloud-based tool called Gloster (Gloster-Page 2012). In all activities, students were required to learn about the tool in order to perform their assignments.

Figure 3: Screenshot of Go-Animate storytelling example.

2.3 Research Methodology

We used standardized instruments by Fishbein and Ajzen (1975) and Davis (1989) to measure this experience; we also use the System Usability Scale SUS by Brooke (1996) and the Computer Emotions Scale (CES by Kay & Loverock, 2008). Through online tests sent to the students with a pre-test and post-test it were measured emotional aspects, usability perception and performance, opinions and motivation about the tools and cloud-based learning activities. Pre and post-test were evaluated with instructional designers, professors and students, to observe and verify its validity for students; some enhancements were introduced after a first review.

The initial test included a section of learning preferences and previous online learning experiences, a survey about the cloud-based tools that were to be used for the experience and their personal perceptions, then a motivation section and finally an emotional aspects gathering section. The post-test included personal evaluation of learning effort using the cloud-based tools for the assigned activities, personal opinions of the experience, motivational aspects, usability and emotional aspects, and open questions about the experience. Since each class of students did two courses, the pre-test was done before starting the first course, then between first and second course, an random telephone interview was conducted, and finally after finishing the second course the post-test was sent to students.

The CES instrument developed to measure emotions related to learning new computer software, by Kay and Loverock (2008), was quite instrumental for this study and includes the following emotions: satisfied, anxious, irritable, excited, dispirited, helpless, frustrated, curious, nervous, disheartened, angry and insecure. The questions were like "When I used the cloud-based tool (and the names of the tools were used) during the learning activity assignment (and each of the assignment's name were cited), I felt ..." Answers used a four point Likert scale from (1) none of the time to (4) All of the time.

The System Usability Scale (SUS) instrument by Brooke (1996) contains 10 items regarding the usability of cloud-based tools used for learning activities. the answers were given on the 5-point Likert scale, so that students could state their level of agreement or disagreement. High mean values indicate positive attitudes and tool evaluations.

The 10 items that composed the SUS questions are:

1. I would use this tool regularly
2. I found it unnecessarily complex

3. It was easy to use
4. I would need help to use it
5. The various part of the tool worked well together
6. Too much inconsistency
7. I think others would find it easy to use
8. I found it very cumbersome to use
9. I felt very confident using the tool
10. I needed to understand how it worked in order to get going.

According to Brooke (1996), SUS has proved to be a valuable and reliable evaluation tool. It correlates well with other subjective measures of usability (eg. the general usability subscale of the SUMI Software Usability Measurement Inventory).

Some of the main standards related to the accessibility that can be applied in cloud-based learning environments are presented in Amado et. al. (2012). It is important to notice that tools and learning activities prepared with cloud-based learning environments should follow international standards (e.g. W3C WCAG2.0, W3C WAI-ARIA) to allow accessibility and usability to all the students, including people with disabilities. The research methodology includes the evaluation of accessibility issues related to the cloud-based learning activities.

Finally, telephone interviews were done with some students and professors randomly selected and only the ones that gave consent to participate on it. Interviewers were instructed to ask about personal opinions regarding the cloud-based tools and the related learning activities, the conversations were audio recorded and transcripts were written.

Using these instruments, the study is presented as an exploratory approach with the aim to demonstrate that students are eager to use and have new and more interactive ways of learning.

3 RESULTS AND DISCUSSION OF THE EXPERIENCE

From a total of 66 students from both groups, 45 of the students gave their consent to participate in the study by filling out at least one out of the two presented questionnaires. Participation were equally distributed with 48% of female and 52% of male participants, (age average M=37, σ=14).

Participants were asked in the post-test and telephone interviews about the experience. Some of the more interesting positive and negative impressions are presented with the emotional aspects evaluation:

Positive impressions:

- "I liked to know new activities and tools in the web for more interaction with the student"
- "I learned about many great tools that will help me with my teaching activities, the experience showed me that the activities can be very interactive and innovative"
- "The use of new tools for learning was fun and can be applied with creativity to teach scientific content."
- "What I liked is that I started using the tools in my current courses."
- "I liked that the activities awaken creativity and obtained interesting results and products."
- "The activities promote meaningful learning, learning by doing so you will not forget, allows flexibility in learning and I feel very satisfying to achieve something new and different."
- "The tools used for the activities are pretty dynamic and will make courses more interactive."

Negative impressions:

- "I needed more time to get to know the tools and how to use it"
- "The work load was increased for activities within the new tools with an overhead with learning the tools"
- "I needed a lot of more time to achieve the results with tools like *Gloster*, and I felt frustrated"
- "The instructions were not clear"
- "With some of the tools you need to purchase a membership to upgrade and enable some functionality"
- "Some of the tools are not accessible and you can't use it in all operating systems, e.g. Flash based tools"

Some of the main results of the post-test were:

- 95% of the participants liked the idea to use innovative learning online tools to represent new knowledge.
- 35% of the participants think that it was difficult to complete the learning activities
- 50% of the participants think that they would need more information and instructions to complete the learning activities.
- Only 10% of the participants expressed the learning activities were boring.
- 70% of the participants considered that the time for the activity was appropriate.
- 80% of the participants were positive about the

expression that sharing results within groups and comments about other participants helps to learn new concepts related to the activity.

The learning experience presents the impressions from participants, which indicates evidence of the interest in learning activities highlighting the interaction, innovation, flexibility and creativity, capabilities that these cloud-based tools seem to easily enable for the participants. The results obtained appear to demonstrate that students are eager to use and have new and more interactive ways of learning, which challenges their creativity and group organization skills.

The following subsections will present related results from an Emotional, Motivation and Usability perspective.

3.1 Emotional Aspects

From an emotional aspect perspective, the instrument was based on the Computer Emotion Scale (4pt. scale) developed by Kay and Loverock (2008) to measure emotions related to learning new computer software/learning tools in general, then the post-test measured the emotions after using the tool proposed for the learning activities with the comparison in Table 3.

Research by Kay and Loverock (2008) in CES showed 12 items describing four emotions:

- Happiness (When I used the tool, I felt *satisfied/excited/curious*.?);
- Sadness (When I used the tool, I felt *disheartened/dispirited*.?);
- Anxiety (When I used the tool, I felt *anxious/insecure/helpless/nervous*.?);
- Anger (When I used the tool, I felt *irritable/frustrated/angry*.?).

The summary with the four variables of the CES scale for groups A and B is presented in Table 4.

The evaluation of emotional aspects from the participants shows little difference in the results between pre-test and post-test measures. In this sense cloud-learning activities and instructor's motivation should focus on improve results looking for students with high level of emotions related to Happiness (e.g. satisfied, excited) and reduce emotions related to Anger or Anxiety (e.g. frustrated, helpless). Results with a 4pt. scale show a positive reaction to "Happiness" and levels of "Sadness", "Anxiety" and "Anger" to improve while working with cloud-based tools used for learning activities.

Table 3: Computer Emotional Scale Comparison.

Emotion	Pre-test results	Post-test results
Satisfied	2.50 (σ = 0.65)	2.48 (σ = 0.65)
Anxious	1.42 (σ = 0.97)	1.24 (σ = 0.78)
Irritable	0.28 (σ = 0.45)	0.44 (σ = 0.51)
Excited	2.33 (σ = 0.72)	2.16 (σ = 0.85)
Dispirited	0.31 (σ = 0.47)	0.28 (σ = 0.46)
Helpless	0.47 (σ = 0.56)	0.52 (σ = 0.65)
Frustrated	0.39 (σ = 0.55)	0.32 (σ = 0.56)
Curious	2.33 (σ = 0.68)	2.12 (σ = 0.83)
Nervous	0.47 (σ = 0.56)	0.60 (σ = 0.65)
Disheartened	0.32 (σ = 0.42)	0.35 (σ = 0.46)
Angry	0.19 (σ = 0.40)	0.32 (σ = 0.48)
Insecure	0.47 (σ = 0.70)	0.40 (σ = 0.58)

Table 4: Summary CES-Scale Comparison.

Emotion (4pt. scale)	Pre-test results	Post-test results	Reliability
Happiness	2.39	2.25	r = 0.75
Sadness	0.30	0.28	r = 0.57
Anxiety	0.71	0.69	r = 0.71
Anger	0.29	0.36	r = 0.78

3.2 Motivational Aspects

Deci et. al. (1991) promotes self-determination and motivation that leads to the types of learning outcomes that are beneficial to the student. According to Deci et. al. (1991), intrinsically motivated students engage in the learning process without the necessity of reward or constraints. Extrinsic motivation, on the other hand, provides student with engagement in the learning process as a means to an end, such as feedback or a grade. For this study and adapted scale based on the work of Tseng and Tsai (2010) was used. The scale by Tseng and Tsai (2010) is used to measure motivations in online peer assessment learning environments. For this study, the instrument measures general attitudes with two subscales for extrinsic and intrinsic motivation. Intrinsic motivation is composed of seven items and extrinsic motivation is composed of four items. A single result is composed for each subscale from the participant answers. Results from the instrument and comparison between the two groups (A, B) using course 3 (e-Moderation), are presented in Tables 5 & 6. Results show a positive measure of individual intrinsic motivation and a regular measure of extrinsic motivation from the point of view of the student related to the perceived motivation from peers.

Table 5: Summary from intrinsic motivation for both groups, means and t-Test results.

Group	M	Σ	*F*	*T*	*Df*
A	76.87	14.43	0.43	-1.58	43
B	84.16	16.13			

Table 6: Summary from extrinsic motivation for both groups, means and t-Test results.

Group	M	Σ	*F*	*T*	*Df*
A	64.97	17.43	0.33	-1.82	42
B	74.97	18.93			

The comparison of Table 5&6, shows an interesting higher value for intrinsic compared with extrinsic motivation when being part of cloud based learning activities.

3.3 Usability Aspects

Students were asked about SUS instrument items regarding usability, in general within the tools used (GoAnimate, Dipity, Timetoast, Gloster, Mindmeister, Cacoo, etc.). Respondents were asked to record their immediate response to each item. Results from the instrument are presented in Table 7 & 8.

Table 7: Summary from SUS instrument for both groups in the experience, reliability and Levene's test results.

Group	R	*F*	*Sign*
A	0.91	2.61	0.11
B	0.70		

Table 8: Summary from SUS instrument for both groups, means and T-Test results.

Group	M	Σ	*T*	*df*
A	65.50	19.51	-2.5	43
B	77.60	13.45		

The results for the usability perception for all the participants are summarized in Figure 4.

The SUS mean combined score for both groups is 72.22. The minimum score is 27 (achieved only 1 time) the maximum score is 100. This is a considerable result that denotes how easily the students have interacted with the cloud-based tools used for learning purpose. The objective of the use of this instrument was to explore about the usability of the proposed cloud-based tools with an acceptable reliability and mean values with great opportunities to be improved.

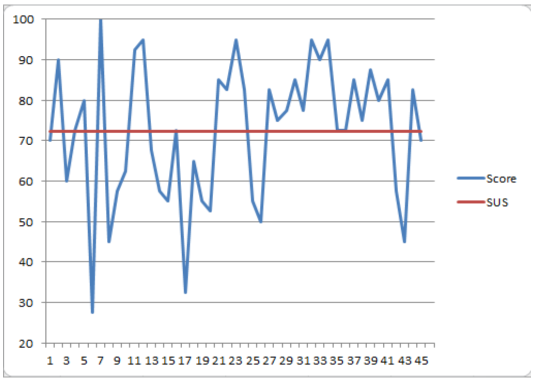

Figure. 4. SUS – Usability of cloud-based learning tools. (Horizontal: participants that fill the instrument, Vertical: Usability score for each participant, the Horizontal line is the SUS mean combined score 72.22).

4 CONCLUSIONS

The results present a low emotional barrier on using a Cloud-Education Environment, which corresponds with the 95% of participants indicating that they like the idea of using this environment. There are high motivation results from the instruments used, and the SUS scale indicates that from the student's perception the cloud-based tools are highly usable.

The results obtained from the motivational perspective appear to demonstrate a high value of intrinsic motivation for students while being part of cloud-based learning activities: this result is an important requirement to engage the student in the learning process without the necessity of reward or constraints.

Analysis from professor's perspective suggest that while doing and planning learning activities, the professor have a growing interest on using new tools and resources that are easy to use, mix and reuse.

The Cloud Education Environment has a promising future and further experimentation is necessary. Still there are many open areas, such as providing integrated systems with high usability, accessibility and interoperability with the aim to create a Cloud Education Environment that can be orchestrated by professors.

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A Knowledge Map Tool for Supporting Learning in Information Science

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Abstract: Large classes at universities (>1600 students) create their own challenges for teaching and learning. Audience feedback is lacking and fine tuning of lectures, courses and exam preparation to address individual needs is very difficult to achieve. At RWTH Aachen University, a course concept and a knowledge map learning tool aimed to support individual students to prepare for exams in information science through theme-based exercises were developed and evaluated. The tool was grounded in the notion of self-regulated learning with the goal of enabling students to learn independently.

1 INTRODUCTION

The Institute of Information Management in Mechanical Engineering (IMA) of the RWTH Aachen University (RWTH) offers a lecture about information science in mechanical engineering (see fig. 1) that is combined with a lab, a group exercise and exam preparation courses. The lecture focuses on object-oriented software development and software engineering (more details in (Ewert et al., 2011)). In a previous semester more than 1600 students attended the lecture. It received good evaluations from students as well as staff. This feedback was taken into account to revise the lecture, the lab and the courses a little further for the summer term of 2012. Here are some of the challenging questions of the revision: (a) How can the student's learning process be supported in a better way? (b) What are the main obstacles the students face when learning programming concepts and techniques of object-oriented programming and software engineering? (c) Which resources are needed to improve the learning process and are these available? (d) How can student-by-student communication be used for peer instruction to relieve the tutors?

The e-learning system L2P[1] of the RWTH is already widely used as a Learning Management System (LMS) in the lecture, the group exercises and the lab. However, additional learning support was requested to assist students in and out of class, but particularly when learning autonomously. Therefore, a Web-based e-learning test bed was designed and implemented which supports different kind of learning situations as autonomous learning, peer-instruction learning as well as e-mail support by tutors. It extended the L2P learning room with interactive and autonomous learning capabilities.

Figure 1: Lecture for information science in mechanical engineering ©David Emanuel.

Additionally, a tool test bed evaluation was designed to analyse how the test bed impacts the students' learning processes. Some research questions addressed were: (a) Are the students willing to use

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[1] http://www2.elearning.rwth-aachen.de/english

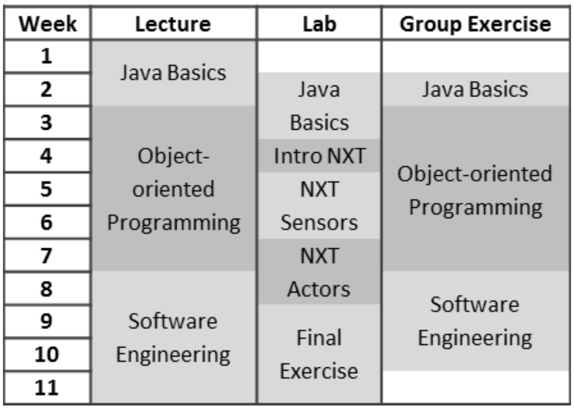
interactive e-learning tools? (b) Is the students' feedback to the teaching staff supported by the test bed, e.g. regarding learning interests and obstacles? (c) Is the test bed capable to support students and tutors in the learning and teaching process? (d) How can the additional challenges of large classes (user management, anonymity etc.) be managed within the test bed?

The rest of the paper is structured as follows: Section 2 will describe the general course design. In section 3, related research is discussed, followed by an explanation of the self-regulated learning concept. Then, the ROLE environment will be introduced (section 4). Finally, in section 5 we will present the evaluation and conclude in section 6.

2 COURSE CONCEPT

The lecture period of the summer semester 2012 started in April and ended in July, followed by a time of exam preparation courses starting in September. The time between these two blocks was used for autonomous, self-regulated learning (SRL). The environment for individual exam preparation was implemented consisting of three ROLE (Responsive Open Learning Environments) widgets, namely a knowledge map, a chat widget and a history widget. In the lab students were able to experiment and actively apply the fundamentals of object-oriented programming with Java. It took place together with the lecture during the summer term from April to July (see fig. 2). The exam preparation courses in September offer the students the possibility to train the addressed competences in smaller audiences.

In addition to renewing the lecture format, the course organisation was updated and supplementary digital material was provided to the students via the RWTH learning management system L2P. The course's L2P was then enhanced by a selection of ROLE[2] widgets, more specifically by widgets supporting self-regulated learning (SRL). Furthermore, another Technology Enhanced Learning (TEL) aspect was introduced into the course by adding a Personal Response System (PRS) sometimes also described as an Audience Response System (ARS). This TEL tool complemented the ROLE technology as it enhanced the opportunity of further active learning prospects for students and also offered an increased interactive setting in terms of the pedagogical delivery.



Week	Lecture	Lab	Group Exercise
1	Java Basics		
2		Java Basics	Java Basics
3	Object-oriented Programming		Object-oriented Programming
4		Intro NXT	
5		NXT Sensors	
6			
7		NXT Actors	
8	Software Engineering		Software Engineering
9		Final Exercise	
10			
11			

Figure 2: Schedule of lecture, group exercise and lab during the summer term 2012.

Previous student evaluations had shown a demand for more self-contained programming occasions as well as practical "hands-on" tasks to try out. The newly designed lab sessions thus offered palpable tasks that the students could carry out completely on their own. The setup for these object-oriented programming lessons was based on working with LEGO Mindstorms NXT (see fig. 3) robots for use by large classes. To support the Java programming language implementation on the NXT controller, LeJOS was used (Solorzano, 2001).

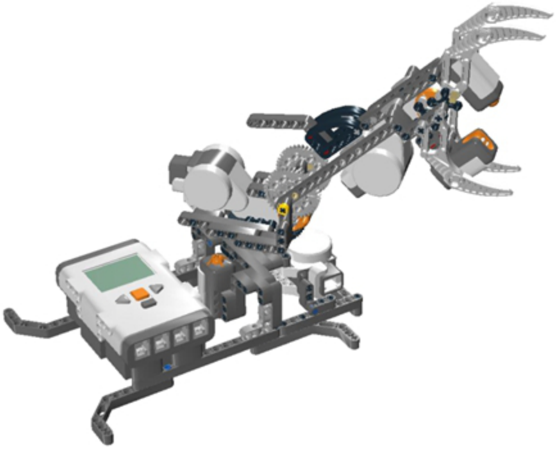


Figure 3: Model of the LEGO Mindstorms NXT robot used in the laboratory (Ewert et al., 2011).

The RWTH ROLE test bed work in 2012 was initiated with a Web-based survey that aimed to collect details about the students experience with e-learning and SRL at the beginning of the lab in April 2012. The ROLE widget environment was introduced to the students during the second week of their studies. The enriched ROLE-based learning environment offered additional support for improvement in SRL opportunities. It also provided particular information about programming in general, related tools, modelling, as well as Java itself. Around 1,600 students participated in the course. All students were informed about the

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[2] http://http://www.role-project.eu/

ROLE-enhanced learning environment offer via several announcements during lectures and labs and via email. During the standard midterm teaching evaluation, a short ROLE-related survey was issued. At the end of the lecture period, the ROLE test bed was also adapted for individual exam preparation during summer time. Finally, after the exam educational staff was interviewed to evaluate the environment and its application within the course.

The lab sessions took place in the largest computer pool of the RWTH which is equipped with approximately 200 workstations. This, however, restricted the maximum number of students that could attend the lab in parallel to 200 students who then worked with 100 Mindstorms NXT robots. Since those 100 robots could not be dismounted and reassembled in each lesson, the lab was based on a standardised and pre-assembled robot model as depicted in fig. 3. This allowed for several student teams to work with the same robot set in consecutive classes and improved the comparability of the students' achievements. (To increase motivation, it would have been desirable that each team had their dedicated construction set. However, this would have resulted in an order of 750 robot construction kits.)

The second part of the lab sessions was based on the principle of problem-based learning. The students were requested to program a robotic gripper inspired by industrial robots. This resemblance to "real" robots was meant to result in a better understanding of mechanical engineering principles by the students. The assigned task was to get the robot to scan their surrounding area for coloured balls, picking them up and putting them into a box. In order to get the robots to detect the balls, students could make use of an ultrasonic sensor, a light sensor and a touch sensor located within the gripper. The robot arm could be moved up and down as well as left and right by directly controlling the corresponding motors. The third motor controlled the gripper hand. The students implemented this task during the remainder of the lab. To allow for progress tracking and giving weaker students a chance to catch up, the overall goal was separated into four sections as described below.

3 RELATED RESEARCH AND SELF-REGULATED LEARNING

The presented approach addresses different recent research issues such as teaching and learning in large classes as well as using cloud services and Web 2.0 applications for e-learning support. The challenge of teaching large classes has been a research issues for many years (cf. (Leonard et al., 1988; Knight and Wood, 2005)). The more technical background of building e-learning tools from Web 2.0 components is being discussed in (Palmr et al., 2009). The approach uses six dimensions for the mapping of Web 2.0 applications to personalised learning environments. The capabilities of ROLE-based cloud learning services are investigated in (Rizzardini et al., 2012). The evaluation shows that cloud-based learning support with ROLE environments is possible but the learners may need introduction and time to be familiar with interactive e-learning tools. The particular aspect of navigation guidance for learning questions in Java programming is discussed in (Hsiao et al., 2010).

Self-regulated learning (SRL) denotes a learning process where the learner herself decides what to learn, when and how (Zimmerman, 1998). Different scholars have attempted to develop SRL models such as the five-component SRL model of (Efklides, 2009), which comprises cognition, meta-cognition, motivation, affects, and volition.

SRL is a central pedagogical focus for higher education in general and the project ROLE in particular. SRL empowers the learners to manage their own learning irrespective of organisational interventions. According to (Steffens, 2006), the quality of learning outcomes varies with the extent to which learners are capable of regulating their own learning. In addition, SRL is considered a core competency for a professional career because of several reasons. Firstly, to keep abreast with the rapid social and technical development of a dynamic society requires life-long learning skills, which entail high autonomy. Secondly, the border between working and learning is getting blurred: we learn while we work by resolving issues in the workplace and we work while we learn by directly applying what we have learnt; SRL skills enable us to integrate seamlessly the knowledge and experience from both realms. Thirdly, it has been shown that self-regulation improves learning outcomes (Steffens, 2006).

Nonetheless, the advantages of SRL can only be realised provided the learner is able to follow a SRL approach. Self-regulation manifestation is a continuum rather than all-or-none. It ranges from an entirely independent pursuit for knowledge and skills to a structured coaching with a teacher working alongside with a learner. In the latter, it could be challenging for both teachers and learners. Amongst others, some salient issues include: learners are not accustomed to deciding learning goals for themselves and thus need some even highly structured guidance; teachers might not be prepared to give freedom to learners while they are still held responsible for their learning progress; organisations might not be prepared to engage learners and teachers in learning scenarios that are relatively open, rendering accreditation or any kind of formal assessment of learning outcomes difficult.

Specifically, in ROLE, the SRL process model is defined as a learner-centric cyclic model consisting of four recurring learning phases (see fig. 4): (i) learner profile information is defined or revised; (ii) learner finds and selects learning resources; (iii) learner works on selected learning resources; and (iv) learner reflects and reacts on strategies, achievements and usefulness (Fruhmann et al., 2010).

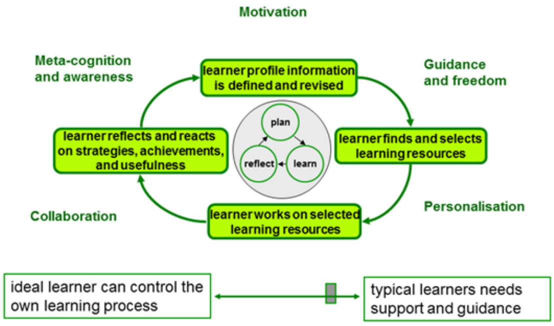

Figure 4: The SRL concept (Fruhmann et al., 2010).

To enable the fulfilment of these learning phases, a learning environment and sets of learning activities should be provided where learners can practice how to learn in a self-regulated manner. The aforementioned learning environment can provide additional learning material (knowledge map) that can be browsed independently, provide help by lecturers and tutors, provide communication channels to exchange with others. That is, support plan and learn. Evaluating the extent to which the students acquire the SRL skills in this way can effectively be measured through a well-designed survey.

4 THE ONLINE LEARNING ENVIRONMENT

In the test bed there are three ROLE widgets: the Web 2.0 Knowledge Map widget (WKM, (von der Heiden et al., 2011), see fig. 5), the chat widget and the history widget. The test bed scenario was deployed for the lab and also for the individual exam preparation of the students in August and September.

The WKM aimed to provide the students with information covered in the lecture and the lab. It was filled with additional SRL-adapted content thus focusing on typical SRL situations such as the exam preparation phase. It contained explanations and motivations for notions, definitions or examples, e.g. for basic Java programming constructs. Background information, e.g. about the installation and usage of the Eclipse programming environment, was provided as well. Exercises for exam preparation were associated with content. These entities of content are called knowledge objects. The presentation and organisation of the WKM followed the paradigm of object-oriented analyses and design in software development. Relations between objects and classes of objects were visualised (see fig. 5) to underline knowledge associations. Functionalities for annotations, remarks and feedback were provided to support individual SRL. For the first time in the course's history, the WKM gave students an opportunity for individual support during their time of exam preparation.

The second widget, a chat widget, was embedded to offer students the possibility to ask and answer topic-related questions. Other students answered the posed questions and, additionally, a tutor also moderated the chat. Finally, a history widget was embedded into the learning environment. It supported the backward navigation within the environment by offering the last five activated knowledge objects. Based on inter-widget communication (IWC, (Renzel, 2011)), the widget used data from the WKM widget to support the learner with his or her own learning history. The WKM was maintained by the IMA, the test bed was hosted by the department of information science at the RWTH and access to the WKM was granted via the login for the lab.

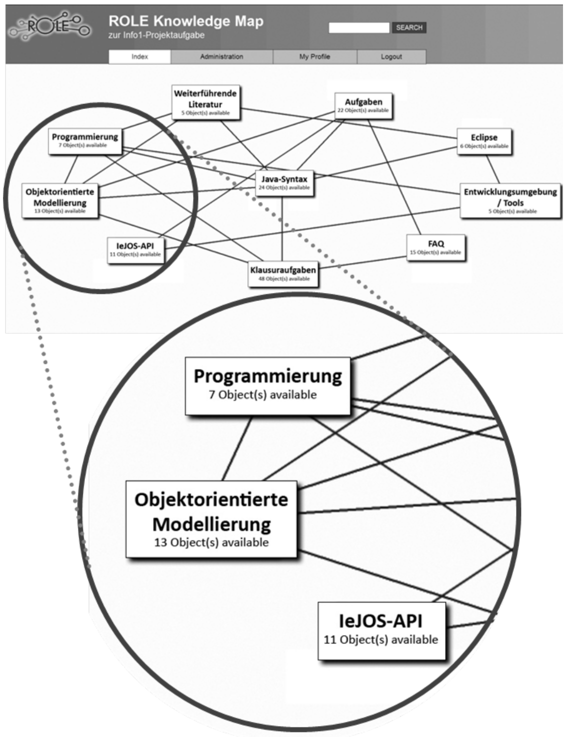

Figure 5: Screenshot of the RWTH WKM (start page).

5 EVALUATION

The ROLE environment was used to some extent during the lab time from April to June. Usage has grown significantly some weeks before the exam in September when the students started their individual preparation. Additionally, the existence and purpose of the learning tools were announced by an email to all students. The access peak was reached in the days just before the exam when students switched to "power learning". This is illustrated by fig. 6 showing the number (by day) of accessed knowledge objects. A knowledge object is a small piece of content as a notion explanation or an exercise. Figure 6 thus underlines the exam-oriented learning during the exam preparation that restricts the leeway in learning and thus the autonomy of the learner. The e-learning environment consisting of knowledge-map, history and chat enables independent and cooperative learning. Moreover, it offers learning flexibility since the environment is accessible at any time; students can use it outside the course hours.

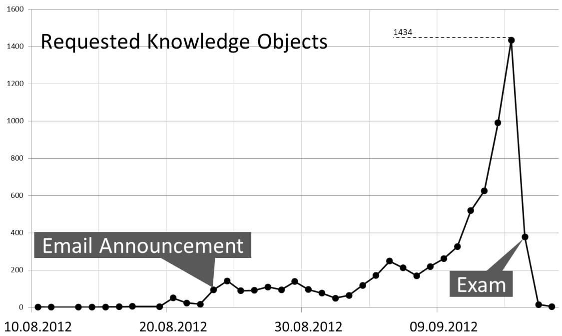

Figure 6: Requested knowledge objects by day.

In June 2012 before the summer break (i.e. at the end of the lab session but before the exam preparation), the students were asked about the usefulness of the e-learning environment and rated it positively. 162 stated that the application of the computer-based learning environment was useful. On the given scale from 1 (strongly disagree) to 5 (strongly agree), the arithmetic mean of the results was 3.7 with a standard deviation of 1.3. Since 3 would be neutral, the students evaluate the environment positively without being stunned.

After the course, the environment has been evaluated by the teaching staff. We conducted four interviews. Three of them with student assistants who acted as tutors within the practical exercise and the exam preparation and who were also responsible for adding contents to the knowledge map and solving technical issues. One interview was conducted with the lecturer who was responsible for the overall coordination and involved in the planning and conception of the whole course.

In the interviews we asked the participants to rate several statements on a scale from 1 (strongly disagree) to 5 (strongly agree) and explain their ratings. Moreover, we asked them to comment on the strengths and weaknesses of the environment and to suggest improvements. The students' positive judgement of the environment has been corroborated by the teachers. For each statement the arithmetic mean (AM) and the standard deviation is given (SD) (in interpreting these measures one has to keep in mind that only 4 persons rated the statements):

- *The environment was useful for the students.* AM: 4.25, SD: 0.43
- *The environment was useful for me in my role as a lecturer/ tutor.* AM: 4.00, SD: 0.71
- *The students reached the learning goals better because of the environment.* AM: 4.00, SD: 0.71
- *I reached my teaching goals better because of the environment.* AM: 3.50, SD: 1.12
- *I would advice the students to use such environments more often if they had access to them.* AM: 4.75, SD: 0.43
- *I would use such environments more often for teaching if I had access to them.* AM: 4.67, SD: 0.47
- *I would use such environments more often for learning if I had access to them.* AM: 3.25, SD: 1.79 (This is an interesting result: Why do the lecturers / tutors rather advice their students to use such an environment than use it themselves? The Interviewees answer that their personal learning style is not optimally supported by such an environment, because firstly they prefer not to browse through learning contents but to study text books and other material, in particular exercises and exam questions from previous semesters, from beginning to end. Secondly, they prefer using pen and paper over doing all exercises with the computer. Therefore, they request an export to PDF so that they can print selected parts of the material.
- *I consider the environment used within his course as a didactically sound means.* AM: 4.50, SD: 0.50

According to the interviewees, the strengths of the environment were, firstly, that the knowledge map gave a clear overview on the course contents and their inter-relationships. The students got a starting point for browsing through the material and exploring the themes independently. Questions could be answered by pointing to specific objects on the knowledge map, and students could (and did) answer their follow-up questions themselves by exploring the surrounding/linked objects. Thereby, the autonomy of the student was effectively supported. Secondly, the chat widget allowed fast feedback from the students. Questions could be immediately answered. Since all students could read the answers, questions did not have to be answered twice. Thereby, the tutors' explanations became more efficient. The tutors saved time for helping with truly individual problems. Thirdly, the environment improved the communication among the students and thereby collaborative learning. After a short time span the students began to answer questions of other students. Fourthly, the environment rendered the students more flexible regarding their time management and learning speed. They were able to repeat lessons and exercises without losing track of the course or thwarting others.

Concerning the weaknesses, the interviewees found technical and usability issues, in particular regarding the administration of the environment and the adding of new contents to the knowledge map. These issues have to be solved but do not affect the concept and general design of the environment. Moreover, the interviewees propose the following extensions of the environment:

- The chat widget should be exchanged or supplemented by a forum for general questions and by a commentary function for the elements of the knowledge map. This would improve the linking of contents with questions and comments.
- They consider a learning planer, consisting of a simple to-do list with links to exam-related material and topics, self-tests and a visualisation of the current level of knowledge/ exam preparation progress (related to the self-test results) as extremely useful.
- The interviewees agree that the contents are the most important feature of the environment. These have to be updated regularly.
- So far the contents of the knowledge map are explored by browsing. An additional search engine for the direct search of specific content would be reasonable.
- One interviewee deems a recommender system that recommends related external material useful.

One aim of offering the ROLE environment was to support SRL. Has this goal been reached, that is, did the environment effectively support self-regulation? The interviewees claim that this is in fact the case. While in the beginning a lot of trivial questions were asked, the students were able to find the answers to such simple questions themselves soon. (The question is, however, whether we can attribute this development to an improvement of self-regulation or rather to a learning effect regarding the course contents.)

The interviewees considered it important to support SRL. They estimated that by far most of their students had medium SRL-level. They correlated the SRL-level with the general knowledge level and acknowledged that students with a high SRL-level learned better and faster. However, as tutors and lecturers they generally preferred to teach students with a medium SRL-level over students with a high SRL-level. They justified this preference as follows:

- A tutor was supposed to lead interesting discussions with high SRL-level students. However, they did not need a tutor that much and therefore did not get in close contact to them. Teaching often did not really take place. Moreover, these students tended to be good students that asked difficult questions. A teacher had to be well-prepared and feel certain on the course topic to cope with these questions. This made it sometimes harder to teach students with a higher SRL-level.
- Medium SRL-level students were intelligent but still requested interaction with a teacher. The teacher got in contact with them, observed the learning progress and saw the positive effect of explanations and assistance. The interviewees found this very rewarding.
- The interviewees considered that a low SRL-level is correlated with rather low learning success. Teaching students with a general low level was considered to be cumbersome and not very rewarding.

Feedback given through the environment was recognised by teachers as very important. The interviewees emphasised the role of the chat (or a forum). Feedback was deemed important for estimating the students' progress and thus adjusting interventions. Moreover, it makes teaching more satisfying.

6 CONCLUSIONS

A course design for information management in mechanical engineering was presented. The course had been re-designed to better support SRL. Therefore, an e-learning environment with several ROLE widgets was provided to the students. The environment aimed to support individual exam preparation. In comparison to the lecture of 2011, the evaluation showed the necessity of intensive promotion for new and additional e-learning tools. Tool objectives and advantages must be clearly communicated (at the right time) to the students. Nevertheless, only a minority of all students had used the test bed for a longer time. Here, guidance with learning questions as in (Hsiao et al., 2010) may motivate students and foster communication. Until now, overview and learning guidance is given by the visualisation of topic relations on the start page, the hierarchical and object-oriented organisation of knowledge in the map and the linking of knowledge objects.

To take stock, the evaluation of this test bed has shown that the environment supports SRL and collaborative learning in large classes. The answering of student questions was easier via the chat widget than by email as all students were able to see the answer. Additionally, the chat fostered student-to-student support. Even if the test bed offered support for early learning, the peak of usage was reached just before the exam. It indicates the students' remaining in power learning.

The test bed was implemented as a cloud learning application combining widgets as services in an overall application and using IWC for communication between the widgets. Since different people were responsible for the particular widgets, it was sometimes hard to fix problems e.g. when server were not accessible.

Until now, the test bed was aimed to demonstrate the possibilities of ROLE technology in large classes. The demonstration was successful and further development has to focus more on the learning requirements of students. Therefore, future improvements are seen in better communication and feedback support to strengthen e.g. learning motivation. Suggested improvements are firstly better collaboration support by adding improving topic-related communication (forum, notepad linked to contents of knowledge map) and secondly better SRL-support by adding a learning planer that supports planning (to-do list) and reflection (self-tests, visualisation of progress). The offering of learning strategies such as learning questions (Hsiao et al., 2010) within the learning tool may offer new advantages and motivation for the students.

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Integrating Cloud Services to Support the Formation of Informal Learning Groups

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Abstract: Cloud Services like Google Drive, Brainstormer, Doodle are meanwhile frequently used as tools for learning in various contexts. They provide storage facilities, production tools and particularly also coordination support. The management of these heterogeneous tools is a challenge for the individual users as well as for the usage in groups. This paper presents a mobile application to support the learners in the formation of informal learning groups and integrates heterogeneous cloud services to support group formation and further group work in a campus environment. Furthermore, this paper tackles the ambiguity of the term cloud application and tries to provide a definition and discusses the process of bringing the Brainstormer web application into the cloud for integration with the mobile application.

1 INTRODUCTION

Nowadays presence-based university studies are supported by a complex and heterogeneous information infrastructure: Course-specific information is typically embedded in learning management systems, with possibly different systems used even in one university. Administrative and organizational information about study programs, general student services etc. is often provided through other information channels. Students access, partially store and further manage this information on personal devices such as notebooks or smartphones. Generally available social media and cloud services may be used to share and further distribute such information. In this sense, a modern campus information environment is an example of a complex, heterogeneous and somewhat scattered infrastructure (cf. (Hanseth, 2010)).

From the given characterization we can directly construe the challenge of better integration. Integration can be addressed from two sides: from the sources (i.e. information and service providers) or from the user (student) perspective. Integration from the source would need to be based on strong premises of being able to change large parts of grown systems. So, in a modest and realistic approach we address the problem from the user perspective.

We have specialized the problem in the form of a typical application scenario: Especially students in their first semesters on campus face the challenge of finding peer groups to collaboratively work on assignments or prepare for exams. This includes the problem of group formation and basic support for group work. As a further specification, we have set a focus on delivering and managing information on personal mobile devices and on considering opportunities in space and time in a campus environment. This conceptual and technical challenge has been addressed in a still ongoing software development project with master level students from an interdisciplinary study program on interactive media and applied cognitive science.

2 RELATED WORK

Providing orientation support for freshmen on campus has been a theme of a number of mobile learning applications (Lucke, 2011), (Giemza et al., 2012), often also using a game-based approach. While these approaches focus on learning the university campus and the surroundings, our application focuses on getting to know new fellow students to form learning groups. The gamification aspect has a lower importance, as we believe that the students have an intrinsic motivation (Ryan and Deci, 2000) to find learning groups for gaining knowledge from others in the collaborative learning process.

Jansen et al. (Jansen et al., 2005) describe a prototypical campus information system that integrates interactive public displays with personal mobile devices and supports personalized and location-aware information transfer. If such an infrastructure (including interactive displays distributed over the campus) were widely available and accessible this would have been an ideal basis for implementing the specific functions supporting group formation and support of group work. However, unfortunately we cannot rely on such premises.

The formation of learning groups has been studied from an intelligent systems perspective using quite sophisticated processing techniques (Largillier and Vassileva, 2012), (Isotani et al., 2009), (Hoppe, 1995). In our case, we do not rely on deep knowledge modeling and intelligent learner diagnosis as input to the group formation process, although this could be considered in future versions. Our starting point and current focus is on opportunistic usage of simple user profiles, general information and coincidences in time and space.

Jansen et al. (Jansen et al., 2013) have classified the usage of existing cloud services from an educational perspective. They distinguish different types of services, including archiving/repository services (such as Google Drive), communication and coordination services (such as Twitter or Doodle) and rich production services beyond simple text messages (such as MindMeister). Still, simple repository or communication services are predominant in many educational applications. A future potential is seen in the area of processing services and especially services for learning analytics.

3 Meet2Learn

Meet2Learn aims at supporting students to meet new fellow students with the goal to form learning groups for their joint lectures. Once the learning group has been formed, the system will act as an organizer to integrate learning materials and other artifacts worked out collaboratively from different cloud services.

In Meet2Learn learning groups are informal groupings organized by students themselves, in contrast to exercise groups offered beside a lecture. Here the learners take the initiative to organize and execute the learning group. Nevertheless they are formed around a lecture that builds the context and the content of the learning group. To support learners in creating and finding appropriate learning groups, the system needs to be aware of the lectures being offered at the University. This will prevent the users to create multiple learning groups concerning one and the same lecture only due to different naming by the learner while searching for a group or while creating it. Furthermore learners need to be represented in the system to provide grouping support based on a user profile. This profile needs to contain the course of studies, the number of semesters and finally the attended lectures. This will empower the system to provide recommendations based on user-based collaborative filtering methods (Resnick et al., 1994). Finally, universities provide various learning management systems (LMS) like Blackboard or Moodle, which can be integrated with the learning groups to import learning material from the lecture as well as to export collaboratively elaborated content back into the LMS. This content will be exported from the “production-type” cloud services like Google Drive or Brainstormer (Collide Brainstormer, 2013).

In the sequel we will explain the components of the Meet2Learn applications in more detail. The target groups for the first prototype of Meet2Learn are students at the University of Duisburg-Essen studying *Applied Computer Science* and *Applied Communication and Media Science*. Therefore the system imports the lectures from the university system called LSF and exports learning groups into a Moodle provided by the university as well.

3.1 Architecture Overview

The frontend of Meet2Learn has been developed as a native mobile Android application. This results in the benefit of a practically permanent availability to the students for checking the status of learning groups and receiving notifications about relevant information. The backend uses an agent architecture on top of a blackboard system (Weinbrenner et al., 2007). This allows for a flexible and extendible design with connection to heterogeneous services using multiple programming languages. The integration of cloud services takes place on the server side through agents as well as directly on the client side through the Android application (see **Figure 1**).

The application integrates the following types of cloud-based services on the smartphone: *Communication, Production* and *Repository*. Twitter and

Facebook are integrated as the first type of service. Hereby students can announce learning groups to their friends that are not yet using the Meet2Learn application. This will increase not only the number of users but also the probability that a learning group will take place with enough participants. Furthermore it will increase the extrinsic motivation (Brophy, 2004) to the learner, as he or she announced the intention to participate in a learning group to the public. Google Drive and Brainstormer are integrated as cloud-based production services. Here learners produce learning artifacts collaborative and link them to the learning group for sharing the results. Dropbox is integrated as a cloud-based repository service. Learners can link uploaded resources and provide direct access through the learning group. The client-based integration makes use of the rich connectivity and extendibility of Android through flexible built-in and third-party APIs.

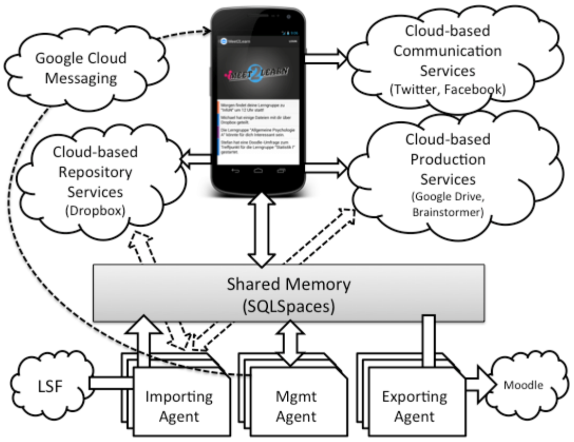

Figure 1: Meet2Learn Architecture Overview.

The server side uses an agent architecture utilizing the SQLSpaces (Weinbrenner et al., 2007) as a shared memory. The agents have different tasks assigned. In the lower left of **Figure 1** importing agents gather data from different heterogeneous sources and import them into the system. The current configuration integrates the study program from the central repository of the university (LSF). This data is used to support the students in adding lectures to their profiles and prevents multiple notations for one lecture. The management agents are responsible for processing data and for controlling the system. One particular feature is the notification of the learners about new events (e.g., a new learning group of interest will take place closely to the users current location). This is implemented by the native Android notification mechanism using the Google Cloud Messaging (GCM) service. Finally, exporting agents integrate learning groups into external systems, like the aforementioned learning management systems (LMS). We are planning to integrate the university's Moodle by exporting Meet2Learn learning groups into Moodle cohorts. This will allow learners to continue the work of a well-established learning group inside Moodle closely located to the lecture.

3.2 Mobile Application

The main entry point for the learner to the system is the Meet2Learn mobile application. Figure 2 shows three main views for the user. The first view (a) represents the main entry point to the application. Here the user finds a "news feed" containing the latest information about learning groups as well as notifications with recommendations and reminders to the learner. The messages are typed by a color tag on the left and can be therefore quickly grasped and identified. A click on the message opens a new view presenting more details about the event. The second screen (b) shows the group creation screen. The learner can configure a new group by setting multiple parameters like the name, time and place and publish this new group to the system. Fellow students can search this group and join it. Finally, the users are responsible themselves to participate physically in the informal learning group.

The last screen (c) shows the details a learning group. The learner can see the title, the participants, the next meeting and finally the resources shared within the learning group using the aforementioned cloud services (here Dropbox and Google Drive). For this purpose Meet2Learn registers itself as a recipient of "share events" of other applications on the Android phone. A user can therefore open the Google Drive app and share the link to a resource with the Meet2Learn app. This will prompt the user to select the correct learning group to share the document with. All participants of this group will receive a notification that a new resource has been shared with them in the shared group. The view (c) also implements the standard share button (top right) that allows the users to publish a learning group on cloud-based communication services like Twitter and Facebook. In this example, the user can share the information about the learning group for the lecture "InfoN" by clicking the share button. The system will present a list of possible (cloud) services to use to process the message. If the user selects Twitter, the system will open the common Twitter dialog with a pre-filled message about the group and

Morgen findet deine Lerngruppe zu "InfoN" um 12 Uhr statt!

Michael hat einige Dateien mit dir über Dropbox geteilt.

Die Lerngruppe "Allgemeine Psychologie A" könnte für dich Interessant sein.

Stefan hat eine Doodle-Umfrage zum Treffpunkt für die Lerngruppe "Statistik I" gestartet.

Veranstaltung wählen: Allgemeine Psychologie A
Anzahl der Teilnehmer: 6
Ort: LF 129
Datum und Zeit: Mi., 8.5.2013 16:0
Kommentar: Bitte an Skript denken!

InfoN
Teilnehmer
Eva Richert
Max Schmitz
Stefan Meier
Nächstes Treffen
Montag, 10-12 Uhr, LF 129
Cloud-Ressourcen
2 Dokumente bei Dropbox geteilt
Eine Präsentation bei Google Drive verfügbar

Figure 2: Meet2Learn App - (a) News feed and notifications (b) Group creation view (c) Group details view.

a link to a web page presenting some more details about the learning group. Then the user can send the tweet and share this to his or her followers. This allows promoting the learning group to other learners not using Meet2Learn and thus allows new users to join the Meet2Learn community.

4 CLOUDIFICATION OF WEB APPS: THE BRAINSTORMER EXAMPLE

In the previous sections we have mentioned Brainstormer (Collide Brainstormer, 2013) as a rich production cloud-based service for collaborative brainstormings on assignments. In fact, we have developed Brainstormer as a Web Application in first place and later deployed to the Open PaaS (Platform as a Service) provider Cloudfoundry[1]. We will use this example and our experiences to discuss what "cloudification" actually means beyond mere web applications and what possible added values can be gained.

There is still no distinct definition or description of the requirements for Cloud Applications. Therefore, this section provides at first our view of a possible definition of the notion of Cloud Application. Based on this definition and on the Brainstormer example, we provide a technical description of steps that are necessary for moving an already existing application into a Cloud Computing environment.

4.1 A Possible Definition for Cloud Applications

Having a look at one of the major definitions of Cloud Computing (Mell and Grace, 2009), a distinction in three different level of abstraction can be found:

1. IaaS - Infrastructure as a Service: Virtual provision of computing power and/or memory. A prominent example of an IaaS service is the Amazon WS service.
2. PaaS – Platform as a Service: Provision of a runtime environment, like application servers, databases etc. Cloudfoundry is an example for a (open) PaaS provider.
3. SaaS – Software as a Service: Provision of usually browser based applications that can directly be used. Here, Google Docs or the Customer Relationship Management software of salesforce.com serves as examples.

Obviously, the only layer the end-user actually interacts with, is the SaaS layer. Therefore, Cloud Applications will be deployed to this level of abstraction. Nevertheless, in order to provide Cloud Computing key factors to the Cloud Application, usually, the SaaS layer will be deployed on top of a PaaS layer running a flexible IaaS environment. Therefore, the first thing to mention for a Cloud Application is, that it needs to run in a Cloud Computing environment, as explained above.

Furthermore, (Mell and Grace, 2009) provides a list of essential characteristics an application needs to provide in order for being called a Cloud Application. First of all, the application needs to provide an *on-demand self-service*, which basically means that the necessary computational resources are provided to the application without human interaction. In the context of learning scenarios, this would mean that a Cloud Application would allow the learner to use the application independent of time and space, with almost unlimited resources. The second aspect men-

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[1] Cloudfoundry - http://www.cloudfoundry.com/ Last visited: Feb. 2013

tioned is the *broad network access*, meaning that the application itself can be accessed via standardized tools and/or off-the-shelf applications (Pettersson and Vogel, 2012). The aspect of *resource pooling* is not that much of interest with respect to the SaaS layer since the provision of according resources is usually ensured by deploying the SaaS layer on top of a PaaS and especially an IaaS layer. Therefore, this characteristic does not provide any new impacts for a Cloud Application within the context of learning scenarios. The fourth aspect, the *rapid elasticity*, yields to the high degree of scalability that Cloud Applications need to ensure. Here, with respect to learning scenarios, this characteristic does not provide new requirements, since, similar to the aspect of resource pooling, this aspect would be answered by a deployment to a PaaS and/or a IaaS infrastructure. Taking a broader view to the question about scalability issues for applications in the context of learning scenarios (Giemza et al., 2012), the question of scalability provides an interesting topic of current research. The last characteristic mentioned is the characteristic of *service measuring*. Here, for Cloud Computing environments, a special need for measuring the service consumption is necessary, especially since the resource provided for the service in question are highly flexible. Again, with respect to learning scenarios, this characteristic is not of high interest as it would usually also be handled on the PaaS and IaaS level and/or there is no special business model for learning applications so far.

Therefore, a Cloud Application in the context of learning scenarios, might be defined as a highly scalable application, both from a technical and a collaboration point of view, that is available via standardized interfaces and with almost unlimited resources.

4.2 Necessary Steps for Moving a Learning Application to the Cloud

In order to fulfill the requirements discussed in the last subsection, there are a couple of steps necessary in order to extend an already existing application to a Cloud Application. We will discuss these steps in general and also in the context of the Brainstormer example.

First of all, the accessibility of the application needs to be evaluated. The overall process for the modification of an already existing application to a Cloud Application is shown in **Figure 3**.

Here, the major question is, whether the application is available to large audience (in our context the learners) via standardized interfaces. Of course this becomes pretty easy in case of web applications, as with Brainstormer, but might be a little bit more crucial with respect to non web-based applications. Here, usually, the question is not only about the user interface with whom the learner usually interacts, but also the question of how data can be added (in terms of input channels (Bollen et al., 2012)) to the applications, might be an indicator for the availability of the application itself. Brainstormer shows also, that these questions are not mutually exclusive, as it provides a web interface as well as an API for third-party clients to contribute content.

The next would be to deploy the application to an IaaS infrastructure. Depending on the architecture of the application, this step might be more or less trivial. Our experience from the deployment of two learning applications to an IaaS infrastructure shows that this step is usually not as trivial as it might appear on the first view. This layer is however already covered when using PaaS providers as Cloudfoundry.

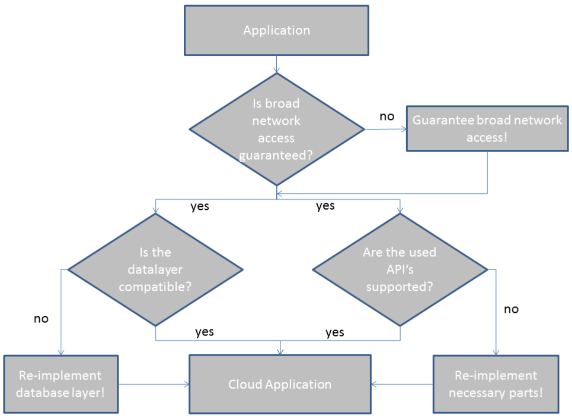

Figure 3: Necessary process for the modification of an existing application to a Cloud Application.

Basically, the problems that usually occur can be subdivided into two different categories. The first category yields towards the data layer of the application. Usually, applications used in learning scenarios depend on some sort of database that stores the developed learning objects and provides additional material to the learner. The examples described in (Giemza et al., 2012) and (Bollen et al., 2012) that we tried to deploy to an IaaS infrastructure, the type of database that the application used before was not supported. Therefore, we had to re-implement the database layer. Of course another solution to this challenge might have been to use our already existing database, but this would have resulted in the question whether we can ensure the necessary scalability, availability and performance of the database. Especially these kinds of problems should be solved by the deployment of the application to an IaaS infrastructure. The case of Brainstormer was easier, as Brainstormer uses a MongoDB database in the backend. Cloudfoundry provides instances of MongoDB, therefore the migration was limited to a re-configuration of the database settings.

The second step for moving an application to a Cloud Computing environment, takes the used frameworks and external API's into account. One of the major characteristics of modern software development is the high degree of re-use of already existing frameworks and API's. Here, it is important to ensure that the provider supports the frameworks and API's used for the development of an application. The usage of standard external services, e.g., Web Services, demands special attention. It needs to be ensured that not only the application itself is highly scalable (from a technical point of view) but also that the used external services are scalable in the same dimension.

Finally we can conclude, that Brainstormer can be considered as a Cloud Application with respect to our definition and the explained steps to migrate a Web Application to a Cloud Application.

5 CONCLUSIONS AND OUTLOOK

The Meet2Learn application is an example of integrating and managing information from heterogeneous sources to support personalized and group learning. It takes the heterogeneity of the surrounding information infrastructure as a given and aims at user-side integration. It combines general information from the campus environment with personal profiles and location information. It also includes the use of several types of cloud services. In this context, the previously developed Brainstormer application for generating and collecting ideas in a group has been "cloudified".

The system will be ready for use in the summer term (starting in April 2013). It will be evaluated with a group of beginners from Interactive Media and Applied Cognitive Science. From a systems perspective, the application will be enhanced by using ontologies and semantic processing for identifying specific user interest and needs.

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Investigating Self-Regulated Learning in the Workplace

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Keywords: Self-Regulated Learning, Personal Learning Environment, Cloud Learning Environment.

Abstract: Self-Regulated Learning, as well as its enabling technologies Personal Learning Environments and Cloud Learning Environments, signify an important shift in the "status quo" of eLearning. These novel learning technologies enable learners to adjust their learning environment and process to their particular needs and aspirations. This paper investigates workplace learning within a wide variety of business sectors in the UK. The scope of this investigation is to determine the current status regarding the adoption of Self-Regulated Learning in the workplace, as well as the opportunities for the deployment of Personal and Cloud Learning Environments.

1 INTRODUCTION

The advent of Cloud Computing has significantly affected eLearning. Learners nowadays have access to a variety of learning tools and services on the cloud. These tools and services are usually provided by different vendors and in many cases are open and free. Augmenting and configuring the diverse and distributed cloud tools and services in order to address the needs and preferences of individual learners is a significant challenge for modern online learning environments.

The Personal Learning Environment (PLE) is a facility for an individual to access, aggregate, manipulate and share digital artefacts of their ongoing learning experiences. The PLE follows a learner-centric approach, allowing the use of lightweight services and tools that belong to and are controlled by individual learners. Rather than integrating different services into a centralised system, the PLE provides learners with a variety of services and hands over control to them to select and use these services the way they deem fit (Chatti et al., 2007); (Fiedler and Väljataga, 2010); (Wilson, 2008).

The Cloud Learning Environment (CLE) extends the PLE by considering the cloud as a large autonomous system not owned by any educational organisation. In this system, the users of cloud-based services are academics or learners, who share the same privileges, including control, choice, and sharing of content on these services. This approach has the potential to enable and facilitate both formal and informal learning for the learner. It also promotes the openness, sharing and reusability of learning resources on the web (Malik, 2009); (Mikroyannidis, 2012).

Self-Regulated Learning (SRL) comprises an essential aspect of the PLE and the CLE, as it enables learners to become "metacognitively, motivationally, and behaviourally active participants in their own learning process" (Zimmerman, 1989). Although the psycho-pedagogical theories around SRL predate very much the advent of the PLE and the CLE, SRL is a core characteristic of the latter. SRL is enabled within the PLE and the CLE through the assembly of independent resources in a way that fulfils a specific learning goal. By following this paradigm, the PLE and the CLE allow learners to regulate their own learning, thus greatly enhancing their learning outcomes (Fruhmann et al., 2010); (Steffens, 2006).

The European project ROLE (Responsive Open Learning Environments; www.role-project.eu) has been investigating ways to empower learners for self-regulated and personalised learning within a responsive open learning environment. In order to study and evaluate the impact of SRL in a variety of learning contexts, the ROLE project has setup a number of test-beds. Each test-bed has concentrated on researching a large sample of formal, informal and workplace learners (Chatterjee et al., 2011);

(Mikroyannidis and Connolly, 2012); (Mikroyannidis and Connolly, 2013). This paper presents results of this work related to the investigation of SRL in the workplace.

The remainder of this paper is organised as follows. The case study of the ROLE test-bed in question is presented, followed by the results obtained from the survey conducted within this test-bed. The lessons learned from the test-bed are then discussed. Finally, the paper is concluded and the next steps of this research are outlined.

2 CASE STUDY

The case study in question is focused on investigating the challenges and opportunities related with SRL in the workplace. It was decided that the most relevant research instrument for this purpose would be to employ a questionnaire survey. The survey was conducted in the context of the ROLE project among the members of the British Institute of Learning and Development (BILD). Effectively, the survey invited the BILD members to talk about their use of eLearning and, in particular, specific aspects related to SRL, as well as those related to PLEs and CLEs.

By way of introduction to this case study, it is important to know that essentially BILD is a subscription-based organisation that supports its own community through a programme of Continuous Professional Development (CPD). BILD has in excess of 1400 members, all of whom work in the area of Learning and Development. Further details about BILD, as an organisation, can be found at http://www.thebild.org.

In order to situate those who were surveyed for this case study it is essential to describe the BILD community constituents. The member organisations vary in size from small enterprises, such as one/two-man-band Limited companies and Partnerships, to large corporate organisations that ultimately support tens of thousands of learners. In this respect The BILD is ideally placed to trial innovation in learning and design approaches in a number of diverse learning scenarios. It can also be seen that BILD members additionally represent the Private, Public and Voluntary sectors thus covering a wide variety of Business interest areas.

The survey-based approach of this case study enabled us to gather relevant information from participants in order to evaluate the emergent findings using inductive investigative approaches via the use of Grounded Theory.

3 SURVEY RESULTS

An online survey was promoted to in excess of 1400 BILD members through personalised emails inviting recipients to participate in the investigation. The survey was open for a period of 1 month. It was noted that some 159 people completed the survey during this period. In addition, a further 7 people completed the survey after the closing date. It appeared that, overall, responses were very positive about the value of learning technologies. Preliminary analysis of the survey indicated that the majority of respondents had used some form of eLearning, for example, with over half the respondents indicating that they had used a Learning Management System (LMS).

The deployed survey revealed an assortment of information that related to the research topic. Figures 1-5 illustrate the collected information, whilst the subsequent section 4 will describe the emergent themes that were identified from the analysis of this information. It also indicates some of the subsequent research that may be possible to develop as a result of analysing the survey results.

Initially, the survey disclosed the variety of business sectors represented by the respondents (see Figure 1). This respondent community covers a wide variety of private, public and voluntary sectors, as previously indicated, which was reinforced by the respondents in terms of their specific sector types. It is important to note, however, that many respondents reported that they worked across several sectors that included public and private. For example, a training provider may have clients in multiple business sectors such as Service Provision, Health and Local Government and work in both the Public and Private sectors, though their own organisation may be Private Sector. Respondents were invited to select ‘other’ if they felt the Business sectors were inadequate. 61 respondents selecting ‘other’ worked in the Private sector, 19 in the Public and 13 in both. 6 selected all three sectors. It should be noted that ‘other’ was often selected in addition to Business sectors from the list.

Respondents also described a very wide set of job titles, often using multiple terms such as ‘Research and training” or “Team Leader” and “Developer”. Figure 2 illustrates some of the recurring titles used. It should be noted that the supporting descriptions provided by respondents make it very difficult to group respondents together. It seems that respondents take on a wide range of responsibilities around learning that may culminate in complex job titles, for example, “Training Executive for Sales and Leadership”.

This paints a picture of a highly flexible sample of respondents with a very rich experience of work environments. It does however mean that the context of research must be very clearly defined in order to get meaningful responses from such a diverse sample.

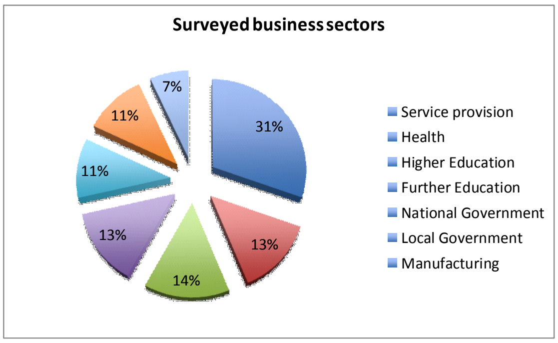

Figure 1: Identified business sector respondents in the BILD survey.

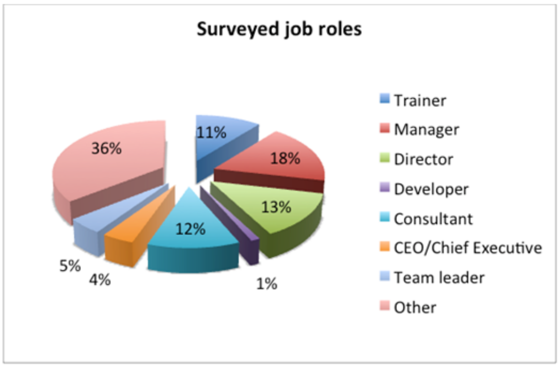

Figure 2: Identified job titles from respondents in the BILD survey.

Figure 3 shows the responses regarding the eLearning technologies commonly used by the BILD members. It is apparent that the surveyed organisations are more familiar with the LMS and much less with the PLE. Regarding the adoption of new eLearning technologies, Figure 4 shows that the individual respondents and the organisations they represent have a positive disposition toward new learning technologies. Finally, the respondents’ agreement to statements related to SRL is illustrated in Figure 5.

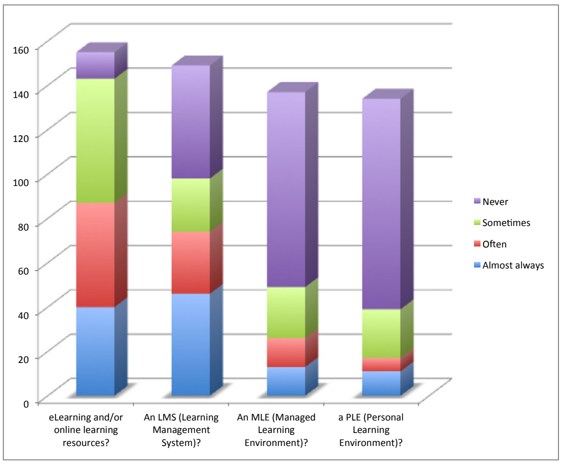

Figure 3: eLearning technologies used by the survey respondents.

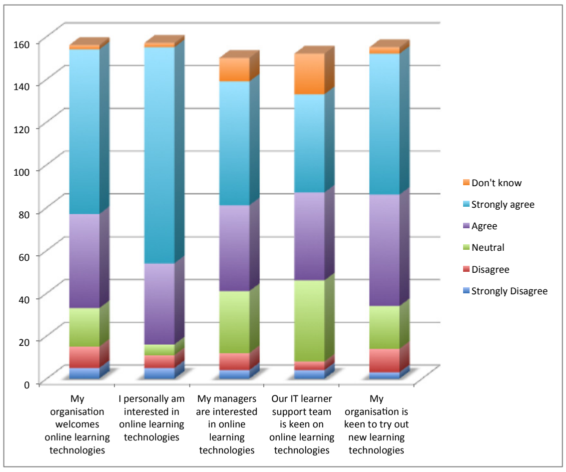

Figure 4: Respondents’ views on learning technologies.

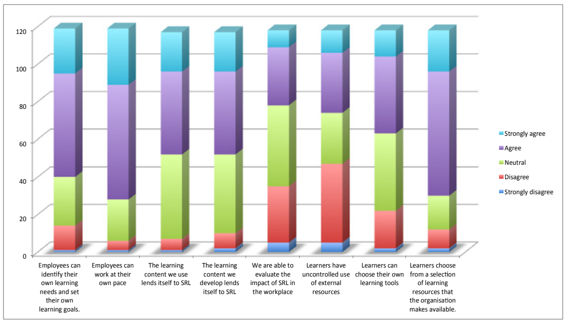

Figure 5: Respondents’ agreement on statements about SRL.

4 LESSONS LEARNED

The survey revealed that there was a perception by respondents with respect to SRL that it was more time consuming for the learner than classroom teaching:

"Time is the greatest barrier to SRL, especially as many learners are contracted so the company needs to ensure that learning is value for money with a minimum of time away from the workplace."

"As I say, time pressures on management often means that training is pushed to lowest priority. If we offered self-paced learning, it simply wouldn't be done. Currently we offer 1/2 day courses at max, which are driven by me in a classroom setting."

It was also indicated by the respondents that learners needed to be 'prepared' in some way, for a SRL approach to learning. By contrast, however, it emerged that a high number of respondents reported that some employees already exercised choice in the type and style of their learning content, their selection with regard to personal goal setting and electing to adopt appropriate tools. These types of responses would merit further exploration and research in respect of the respondents understanding of SRL and the contexts where it is used. An example of this approach is:

"elearning and materials are made available on our LMS through external resource link such as (BRAND). Main barrier is communicating these resources to employees and encouraging employees to be proactive."

Other information that emerged from the survey indicated that respondents were interested in finding content to support specific skill and knowledge areas. There was also evidence of further high levels of interest by respondents in evaluating and trying out new content. It is important to note, however, that some BILD members are actually developers of learning software. This type of work tends to be highly bespoke and often directly defined in terms of the learner's experience i.e. learners progress through an instructionally designed learning package.

Additionally, most of the survey respondents appear to concentrate on the idea of a blended learning scenario, where online learning is an adjunct to more traditional learning, to deliver specific learning skills e.g. Customer Care scenarios/videos, can be achieved. Finding high quality content and the evaluation of eLearning against more traditional teaching approaches was raised as a concern for example:

"At present we have made strong progress in the supply of materials and options but we now need to evaluate their usage and impact on learners."

"The biggest issue for us is lack of quality learning material available on-line that are directly relevant to sales people."

It is clear from the survey that the BILD respondents, generally, are keen to try new learning technologies themselves. Nonetheless, they need to have evidence of their effectiveness in order to persuade their clients to adopt, use or incorporate such learning technologies, particularly with those organisations where more traditional learning approaches are currently used. It would appear from the survey responses that eLearning for many BILD members tends to take the form of complete learning packages that lead the learner through a designed series of learning experiences. Assessment is usually tested within the learning package for instance respondents remarked that:

"Most learning topics are provided by the company in a structured way. However more than 500 e-learning titles are available to all employees 24/7. "

"Learners are encouraged to choose - from a range of modules - those which will provide for them the most appropriate enhancement to their chosen Modern Apprenticeship programme."

The survey also indicates that many BILD members continue to have an interest, or perceive they have a vested interest, in prolonging face-to-face teaching as the only effective delivery method. This would appear to be generally related to the experience of delivering training in the workplace, clients expectations and the condition of systems available and the available work in areas of compliance training. The following quotes from survey respondents reinforces this point:

"In general, organisations I work with prefer face to face learning".

"Training is almost always selected on operational need and thus delegates must attend certain courses to have authorised access to systems"

"SRL is currently overshadowed by the understandable prioritization of Statutory and Mandatory training, in these times of efficiency savings."

"This seems to be a very nice idea for some sectors but has limitations when organisations need to ensure employees have required knowledge and many are not very good at identifying their own learning needs as they assume knowledge they only partially have".

> *"We provide basic e-learning courses, from which learners can choose. Most training to-date is classroom based and tutor led."*

> *"A lot of our training is technical, mandatory, Health and Safety related training and with such compliance culture not many learning options exist for the student. They do what they must do to remain suitably e-qualified."*

Despite the various barriers to SRL and eLearning, the majority of respondents saw potential in eLearning and welcomed the opportunity to get involved for example:

> *"Very interested in PLEs as they are clearly the way learning needs to go. Happy to be involved with any workshops, developer opportunities and being involved in any pilot studies, etc."*

> *"I would like to be able to use this opportunity to introduce development staff at Education Business Solutions to these tools - so they can evaluate them in the context of working with teachers and secondary school children"*

There were also respondents who presented as mature eLearning practitioners who were keen to extend their knowledge of PLEs and CLEs. They noted that:

> *"We provide diagnostics and the learner is encouraged to determine their own development priorities and approach."*

> *"I currently promote ePortfolios (eFolio) as the tool to support independent study, mentoring, peer-review and collaboration."*

Nonetheless, in terms of lessons learned, it has emerged that further work needs to be carried out in a number of the investigated areas, for example, in evaluating specific learning technologies and drawing comparisons with other teaching approaches. It can also be noted, at this point, that the BILD community has many members who specialise in the area of empirical research and, as such, can be encouraged to try out and possibly adopt new learning technologies, such as PLEs and CLEs.

With this in mind, the BILD has offered in the context of the ROLE project a series of webinars and seminars to its members, covering a variety of SRL-related topics. These events have targeted a broad audience, including those non-developers who are mainstream trainers, and have enable BILD members to be introduced to the concepts and applications of SRL. The ROLE project has used these events in order to engage with a specific learning community and promote PLEs and CLEs as an innovative and representative learning catalyst for an existing learning community or membership group i.e. BILD. This has offered the opportunity to those participating to explore key issues, and raise awareness about the perceived barriers and benefits of the SRL approaches to learning.

In order to further motivate and facilitate the adoption of SRL within this community, we have also endeavoured into developing and delivering multi-format learning materials about SRL. These learning materials are freely available as Open Educational Resources (OER) and consist of:

- An *online course* about the principles of SRL and the tools that enable it (http://labspace.open.ac.uk/course/view.php?id=7898). The course introduces the concept of SRL and guides learners into using the ROLE tools in order to apply the SRL principles into their own learning.
- An interactive eBook about PLEs and SRL, available for iOS devices (http://projects.kmi.open.ac.uk/role/ibook/ROLE.ibooks). The eBook provides an introduction to PLEs and SRL and gives an opportunity to readers to try a selection of ROLE widgets through a set of interactive learning activities included in the eBook.
- An introductory video about SRL, available in English, German and Chinese (http://youtu.be/jTa1vOH6JjA, http://youtu.be/UkAkFQ5TPOI and http://youtu.be/yRy5ZLT3jQQ). The video explains the basics of SRL through a simple example involving tourism and travel.

5 CONCLUSIONS

In summary, the case study of the BILD membership organisation has been carried out within an identified learning community belonging to a wide variety of business sectors. It involved the deployment of a questionnaire survey and the analysis of the results. The results obtained have helped us gain an insight into some of the challenges and opportunities for enabling SRL through the use of new learning technologies in the workplace.

What we foresee as the next steps of this work is the closer involvement of business stakeholders and the collaboration with them in order to bring PLEs and CLEs closer to business requirements. We plan to collect case studies of stakeholders sharing their experiences through describing their learning processes as individuals in addition to being seen as sharing that representation with the wider learning community. This would serve both as providing research evidence as well as valuable learning resources for the wider eLearning community too. This would also provide empirical evidence of the value and benefits of the SRL approach.

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Integrating Various Cloud Computing Services in a Collaborative Geo-referenced Learning Scenario

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Keywords: Collaborative Learning, Cloud Services, Software Architecture.

Abstract: Some of the main characteristics of Cloud Computing are reliability, scalability and ubiquity. This makes it especially suitable to support large groups on learning activities that require computer support in various settings, in and outside the classroom. In this work, we first analyze the use of Google Maps for supporting a learning activity in an urban environment, concluding that some important features are missing. We then propose an approach for taking advantage of cloud computing services for learning activities by integrating different services in a new application.. A general architecture explaining this approach and a design for such an application as example are finally presented.

1 INTRODUCTION

Cloud computing, in all its modalities, is increasingly being used to support collaborative learning activities, especially for those involving large groups (Antunes et al., 2011), since scalability is one of the most prominent characteristic of it.

According to (Tan and Kim, 2011), the benefits of using cloud computing to support learning are following: cost saving, flexible IT management, and accessible IT Resources and Services, because the services they provide are accessible from any device connected to the internet like desktop PCs, laptops, tablets and smartphones.

On the other side, they point to some risks: *reliability*, because vendors of cloud services will never provide 100% reliability; *control*, since the services reside and are controlled by the vendor; *security* and *privacy* because the lack of control also may lead to the risk of security or privacy breaches; Organizational Learning, because users of cloud services (students and teachers) might need to learn a new way to interact with the software. Moreover, in (Masud and Huan, 2011) authors say that public clouds may offer low-cost services, but in return they may not provide needed assurances of security for those services. They also refer to the need that Software-as-a-Service (SaaS) has to be customized to meet the needs of various customers. However, providers cannot afford to develop and maintain a version of application for each individual customer.

This work first presents an experience in which a well known cloud service, namely Google Maps, was used "as it is" in order to support students of a pre-graduate university course about business and TI, in which they had to propose, discuss and rank ideas in which IT could be used in certain parts of the city in order to solve problems or improve citizens' daily life. A questionnaire was applied to the students in order to find out in which degree did the software meet the needs for performing the requested collaborative learning activity. Analyzing the answers we found that they appreciated many of the functionalities provided by the site.

However, they also pointed out to some important drawbacks, such as the lack of private workspace, security problems, delayed synchronisation and the basic mechanisms for supporting decision making: a public discussion space and a mechanism to rank the solutions/ideas they generated during this work. Based on these results, we present here a new development, which uses services from the cloud as building blocks for developing an own application customized to meet the needs of the particular leaning scenario involving a large group with the minimum effort, programming only the "glue code" to integrate these blocks and implement the missing functionalities. The development has the following characteristics:

- It uses de cloud computing services from Goggle Maps in order to show maps and associate specific data objects to certain geographical locations, which represents the ideas proposed by the students.
- It uses the cloud computing services from Twitter in order to implement students' participation to Rank ideas.
- It uses Facebook Authentication services to register and keep track of what students contribute to the discussion.
- Implements freehand writing and sketching over the maps.
- Implements on-time synchronism on the objects which are created/modified on the map (sketches, location marks, photos, comments, ideas ranking)
- Stores the important data in an own server using a XML format.

In this way we also address some of the problems related to control and security inherent to cloud services mentioned before. This approach has many ideas in common with the one presented in (Jansen et al., 2012), in which cloud services such as Twitter, Facebook, even SMS and e-mail are used as data input channel for various learning applications. One of the main ideas we share is from the software engineering point of view, which considers that cloud services may be integrated into a new application in order to reuse available, well implemented and scalable functionalities.

2 RELATED WORK AND DEFINITIONS

According to (Sultan, 2010), cloud computing is an emerging computing paradigm which promises to provide opportunities for delivering a variety of computing services and that educational organizations are already taking advantage of the benefits.

According to (Alabbadi, 2011), cloud computing will significantly impact the educational and learning environment. They propose the use of cloud computing in the educational and learning arena, to be called "Education and Learning as a Service" (ELaaS).

Some studies explored specific cases where Google Document, Google Presentation, and Google Maps are used to facilitate collaboration in learning contexts. In (O'Broin and Raftery, 2011) authors explored how Google Docs overcome some limitations in project-based learning. They report that work with project-based learning has limitations related to students' difficulty to collaborate on artifacts outside the class, and that it is problematic for the teacher both to monitor the progress of the project, and to assess the individual contribution of each student. Authors say these limitations are partly overcome by Google Docs, because: (1) it enables students in different locations to work simultaneously but independently on the same artifact; and (2) teachers can be included as observers on each project group and thus track the development of the work. However, students also identified some limitations of simultaneous editing of Google Docs: if two or more students edit text in the same region of a document, one of the students will receive a message informing the student that his/her text has been discarded, spontaneous deletions of text, and confusion caused by the auto-save feature.

Cloud computing for learning environments has different groups of stakeholders, with different information needs (Masud and Huang, 2011): students rely on IT for communication and information searching; teachers pervasively utilize IT to deliver individual or collaborative task (e.g. using Google Docs, Google Maps, etc.), lectures, manage course materials, and provide speedy feedbacks to students; administrators use IT-based information systems to manage registration, human resource, and accounting. A case study methodology was applied, in order to investigate the use of Google Docs as a free cloud computing based product (Masud and Huang, 2011). The results obtained indicate that MBA students held positive impact on perceived usefulness and satisfaction about using Google Docs. In (Kumar, 2009) authors report that undergraduates students found that Google Docs helped them to complete large amounts of work online by allowing them all to work on a document without need to meet all at the same time.

In (Chu and Kennedy, 2011), Chu and Kennedy describe an experience about using MediaWiki and Google Docs at undergraduate level as online collaboration tools for co-constructing knowledge in group project work. Students used MediaWiki for project during a knowledge management course and Google Docs for completing a final year project. Results indicated that some of the students had positive experiences using the tools for online collaboration in the group projects. According to this report, MediaWiki and Google Docs gave teachers the facility to closely monitor student progress, and provide feedback to assist in the effective management of the report-writing process. Thomas (Thomas, 2011) also explores the potential of cloud computing in an educational setting using Google Docs.

Fluke reports a pilot study on the use of Google Maps to provide virtual field trips as a component of a wholly online graduate course on the history of astronomy (Fluke, 2008). The Astronomical Tourist Web site (ATsite) is an example of how Web 2.0 applications (mash-ups) can be used to build new online learning environments. The use of Google Maps was used to support virtual field trips. It helped to clarify and strengthen the connection between the places and people involved. Students could share their experiences visiting locations, personalizing the learning experience. By encouraging students to seek out locations active learning was undertaken.

From the literature review, we can conclude that free cloud services offered by various providers have been used to support learning activities. Most cases report that the cloud service was used “as it is”, except for (Fluke, 2008) and (Jansen et al., 2012), in which APIs of different cloud services were used in order to create a new application. In this work, we intend to systematize this approach in order to develop learning applications combining various services offered by the cloud and integrating them in a new learning application.

3 EVALUATING GOOGLE MAPS “AS IS”

As seen from (Fluke, 2008), learning can benefit from making use of the services provided by Google Maps, especially those in which the knowledge to be acquired is related to information with a strong association to a geographic place. Other examples are described in (Otaga et al., 2006) and (Zurita and Baloian, 2012). In our case, we decided to first make an experiment in order to have some insight about the suitability of Google Maps to support certain collaborative learning activity involving a large group of students.

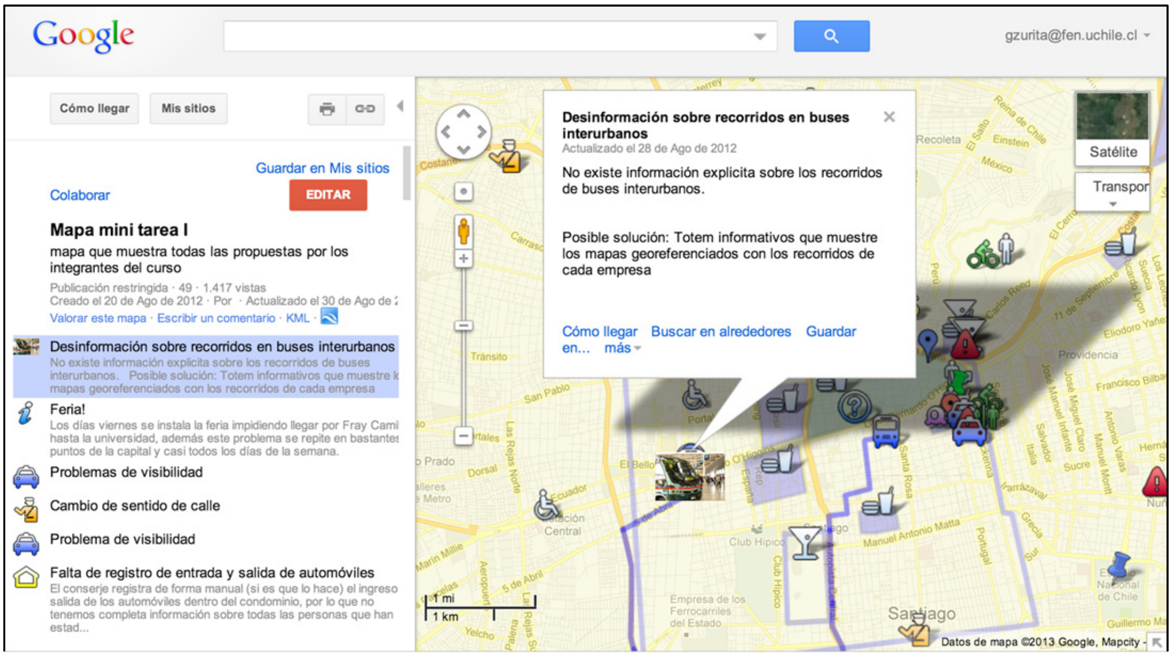
We used the same methodology, experiment design and applied a similar questionnaires in the work reported in (Antunes et al., 2011). However, the results were analyzed for a different purpose: this time the focus was to find out which functionalities were missing or not properly supported to accomplish the task.

The experiment involved students from an undergraduate course undertaking a collaborative design assignment to identify problems and/or opportunities in a urban area and propose innovative solutions based on information technology. They were asked to accomplish the assignment using Google Maps. This assignment was given during the second semester of 2012. The sample consisted of 46 students, 28 male; average age 22.3, taking an undergraduate course on Computer Science, in the eight semester of Information and Management Control Engineering, at Universidad de Chile. It is expected that students at the end of the course are able to: (a) detect problems and identify opportunities in an organization, that may be supported through IT; (b) manage an IT strategy that can introduce competitive advantages into an organization; (c) design IT solutions; and (d) develop communication and teamwork skills. These students were good users of computing technology because 35% use notebooks or tablets in classes and most have smartphones, all use PC at home. They regularly use popular desktop software; and use social media tools like Twitter, Facebook and MSN.

The task was performed collaboratively outside regular classes. All students were part of a single team. The teacher explained the task in the classroom, recommending the students to observe an area and identify problems, opportunities and ideas that may be addressed using IT, which should be geo-referenced in Google Maps. Each student should deliver at least two ideas. Students were also asked to discuss and give their opinions on the classmates’ ideas and collaboratively choose the ten best by mutual agreement. Students had one week to perform the task. No instruction regarding the type of hardware to be used or the coordination mechanism to select the best ideas was given. They were just told they should use Google Maps. Consensus rules, task awareness and coordination mechanisms had to be established by the students themselves.

Following the instructions, students performed the task accordingly. Most pictures were taken with mobile phones and uploaded in Google Maps later. The resulting documentation of the activities done with Google Maps may be seen in Figure 1.

The students filled in questionnaire with three questions: (Q1): “did you feel information overload during the task?”, (Q2) “how easy was the software itself to use”, and(Q3) “how easy to use was the collaboration support?” Students were asked not



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Desinformación sobre recorridos en buses interurbanos
No existe información explicita sobre los recorridos de buses interurbanos. Posible solución: Totem informativos que muestre l mapas georeferenciados con los recorridos de cada empresa

Feria!
Los días viernes se instala la feria impidiendo llegar por Fray Cami hasta la universidad, además este problema se repite en bastante puntos de la capital y casi todos los días de la semana.

Problemas de visibilidad

Cambio de sentido de calle

Problema de visibilidad

Falta de registro de entrada y salida de automóviles
El conserje registra de forma manual (si es que lo hace) el ingreso salida de los automóviles dentro del condominio, por lo que no tenemos completa información sobre todas las personas que han estad...

Desinformación sobre recorridos en buses interurbanos
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Posible solución: Totem informativos que muestre los mapas georeferenciados con los recorridos de cada empresa

Figure 1: A Google map collaboratively geo-referenced by the students. On the left side, the list of problems, ideas and comments are shown. Geo-references are displayed as icons on the map representing the location for these ideas.

Table 1: the positive and negative comments associated with the Q1.

Q1: Did you feel information overload during the task ?			
Positive comments		**Negative comments**	
2	Everyone was available on the computer screen	19	Too many ideas and comments shown at the same time
1	Work was performed orderly	6	Some contributions were duplicated
1	History of ideas was easy to follow	2	Considerable flow of ideas and feedback
		6	Relation between ideas and comments difficult to establish
		7	Related ideas are shown apart from each other
		2	Too many objects shown in the same window at the same time
		2	Some comments were simply forgotten

Table 2: the positive and negative comments associated with the Q2.

Q2: how easy was the software itself to use*?*			
Positive comments		**Negative comments**	
10	Easy to understand	8	Proximate comments are difficult to discern
3	Immediate visualization of new comments	6	Cannot see who deleted comments
2	Reference of ideas in geographical context	7	Lacks coordination support
2	Using of colors	6	Mapping and chatting unrelated
2	Using of text and pictures	2	Slow
1	Use of icons	2	No private working space
1	Easy access to ideas	1	Had to improvise in order to collaborate
1	Searching	1	Difficult to merge comments, ideas
		1	Communication is not primarily focus

only to give a quantitative answer but also mention positive and negative aspects of the software related to the question. The results are shown in Tables 1, 2, and 3.

The comments to Q1 indicate that the flow of ideas was very high, making it difficult to follow and easy to forget. Also, the number of repeated ideas was considered high. Very few comments were given on the positive side. The most relevant observation was that the participants liked having all information visible on the computer screen.

Comments to Q2 reveal several technical issues contributing to the perceived low usability. The most frequently cited one is a usability problem related with uploading photos. Two other ones concern difficulties discerning comments when their locations are very proximate, and lack of information regarding who deleted others' comments.

Within the collection of negative factors, we also find references to more conceptual problems regarding the task organization. In particular, the participants pointed out a disparity between mapping and commenting ideas, the fact that communication is not the primary focus of Google Maps, and the need to improvise collaboration strategies, since the tool does not offer clear support in that area.

Table 3 reveals a large set of negative and positive factors regarding collaboration support, although with clear emphasis on the negative side. Within the negative factors, two of them were very preeminent: the group had to develop a coordination mechanism (using Google Docs) since the tool does not provide a native solution; and the problem that any participant may modify or delete comments without control or rollback. Within the positive factors, the most significant ones were the support for sharing ideas, obtaining and giving immediate feedback about the ideas, and asynchronous interactions. Students also mentioned that besides having to devise an alternative scheme to collaborate they also had to designate a facilitator.

Table 3: the positive and negative comments associated with the Q3.

Q3: how easy to use was the collaboration support?			
Positive comments		**Negative comments**	
4	Shared view of ideas	14	Group had to develop alternatives for coordinating group work
1	Easies problem understanding	12	Users can edit others' contributions
1	Facilitates view of task progress	7	Tool inadequate for discussion support
2	Permits asynchronous interaction	1	Difficult to converge
1	Easies time management	1	Asymmetric participation
1	Uses colors	1	Lack of chat tool
		1	Lacks awareness mechanisms

4 PROPOSAL FOR AN INTEGRATED APPLICATION

In (Tan and Kim, 2011) authors state that the match between the attributes of a particular technology and the characteristics of the tasks to be supported by this technology is one of the critical success factors in IT adoption and implementation. Based on the comments given by the students about the missing functionalities we propose in this chapter (1) a general architecture for developing applications to support learning activities for large groups integrating cloud services; (2) a new application based on this architecture, which implements most of the functionalities that were considered important but were not provided by Google Map "as is".

4.1 A General Architecture

The starting point for our proposal is the SOA approach for software development and the conceptual basis elaborated in (Jansen et al., 2012), essentially an architecture that takes advantage of the already existing "cloud services" for collecting inputs and in this way achieves an improved "accessibility" of the overall system. Our approach here goes one step further by proposing that various cloud services could be used not only for facilitating data input in a convenient way but also for other functionalities. In the particular case of systems for situated, location-dependent learning activities based on geo-collaboration we see at least the following additional functionalities to be integrated using available cloud services:

- Maps: Maps are an important element for many applications supporting field trips. Today they can be downloaded from various sources: Google Maps and Open Layer offer 2D maps, Google Earth offers 3D maps. They offer APIs in order to download and manipulate maps.
- Authentication: Many learning activities require identifying the student who generates learning material or performs an activity. Google's or Facebook's authenticator may be used to incorporate this functionality in a new application.
- Discussion board: Social networks like Twitter or Facebook, as well as other Cloud Services may be used to implement the input text for these facilities.
- Synchronization: Real time synchronization of data is frequently necessary. Cloud Services like Google App engine, Microsoft Window Azure or Amazon's Elastic Compute Cloud could be interesting platforms to be considered for implementing this part of the system.
- Data storage: For this, there are many possibilities which offer APIs to store data in varied formats: Amazon S3, Apple iCloud for Cloud storage service, Dropbox for files, Google Storage , KIT Video API among many others.

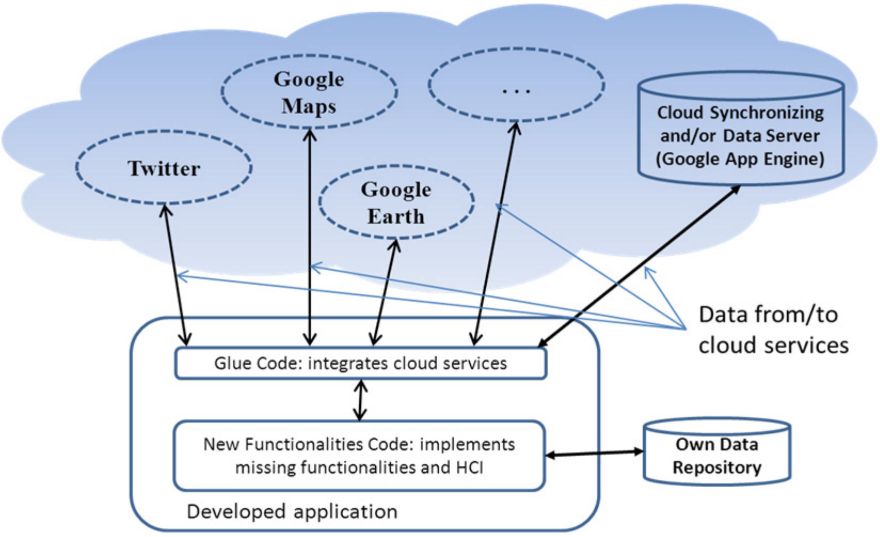

Figure 2: The picture shows the logical general schema of the proposed architecture.

Figure 2 shows a logical schema of the proposed general architecture for supporting geo-collaborative learning activities with key functionalities provided through cloud services. The new application has a "glue–code" component implementing the communication with the cloud services through their APIs by sending and receiving data and/or invoking functions. This part also interacts with the code that has been developed in order to implement additional functionalities not provided by the cloud services, including the user interface. This part of the code may also in some cases implement functionalities for data storage in an own server or repository in the case that available Cloud Services may not match the requirements needed. This can, for example, be due to the data format, or because the data to storage may be sensitive (priovacy). In order to guarantee a maximum portability of the developed applications, our approach proposes to develop the applications using HTML5 and JavaScriptas a common deniominator between a variety of platforms, including desktop PCs running Windows or Unix, tablets and smartphones running Android as well as iPads running iOS. With its new features, HTML5 is capable of implementing rich interactive applications running on a browser (Baloian et al., 2011).

4.2 A Reference Architecture

According to the students' comments, some of the problems were related to the lack of coordination and awareness mechanisms. For this reason, it was difficult to keep track of the work process. To overcome this problem, we first propose that students should be individualized in order to associate their contribution to their login name and establish an authorship property for these contributions. This may be accomplished by the authoring services in Facebook, since Facebook also provides the functionalities for implementing discussion boards with non-anonymous contributions.

Another coordination problem was the lack of a mechanism allowing to rank the ideas and suggestions. For this we propose to integrate the like/dislike of twitter, since is a well know mechanism and it is easy to integrate. Facebook offers a similar functionality. We select Google Maps in order to integrate the maps because of the simplicity of the tasks that need to be accomplished. Google maps also provide api services: routes, distances, elevations, geocoding and places. Thus the "glue code" implements the conversation with Facebook, Twitter and Google Maps through their APIs and renders the graphical elements received from the services. Additional code has to be developed in order to implement private and public workspaces as well as switching between them and passing data from the private to the public workspace. Due to the characteristics of the data generated by the system and related privacy issues, it is not possible to use an external cloud service for sorage, so a specific dedicated server has to be used. For the same reason, it is also impossible to implement the synchronization of data for the public workspace with an external service. This will be implemented using a mechanism developed earlier by the authors which allows easy synchronization of

Gandarillas, 49-159, Puente Alto, Santiago Metropolitan Region, Chile, 2011-09-05 17:17:47:
57dbuv friss

Condes, Lo Barnechea, Santiago Metropolitan Region, Chile, 2011-09-05 17:17:20:
79

Independencia, 6001-6043, Conchali, Santiago Metropolitan

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Icon for switching to private workspace

Contributed ideas ranked by twitter's like/dislike functionality

Comments to ideas associated to author and grouped by idea

Maps obtained from Google Maps over which various levels of information are implemented

Facebook authentication and comments input & management

Figure 3: Mock-up of the interface for the proposed application.

applications developed in HTML5 called "couple objects" [15].

5 CONCLUSIONS

Some of the main advantages that authors have mentioned about Cloud Computing are scalability, ubiquity, and reliability. These characteristics match the requirements of many learning scenarios, especially those in which students have to perform learning activities across various setting, inside and outside the classroom, collaboratively and individually working on generating and analyzing data, using different kind of computing devices supporting this work. This work proposes the use of cloud computing for learning in a different way as reported by the literature: instead of using services as they are offered we propose to combine them in a new application which can be tailored to meet the requirement of a specific learning activity taking advantage of the characteristics of cloud computing and getting rid of at least some of its drawbacks.

We first analyzed the potential of using a popular cloud computing service to support a collaborative learning activity with a large group of students, understanding large by more than 20 individuals. Although Google Maps was able to provide a number of functionalities required to accomplish the task, it was clear that student missed other functionalities which would have helped a lot. This leads us to the idea that cloud services could be combined and integrated in a new application tailored especially for the learning requirements saving considerable development efforts. We present this idea as architecture for developing applications using this approach. Based in this, we present a preliminary design for an application which matches the requirements for this learning activity including the missing ones. The feasibility of this approach has been already proved by previous applications implementing this approach to some extent (Jansen et al., 2012); (Baloian et al., 2011).

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