Application of qualitative reasoning models in the scientific education of deaf students

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Abstract

Regarding the education of deaf students (in Brazil), three conditions have to be met in order to bring qualitative reasoning (QR) models into the classroom: (a) a bilingual education should be provided, the Brazilian Sign Language (LIBRAS) being the first and Portuguese the second language; (b) in the absence of scientific vocabulary in LIBRAS, it has to be created; (c) given the aural impairment, which is cognitively compensated through an over-developed visual ability, a visually oriented pedagogy is needed. This paper describes how qualitative reasoning may provide an adequate scenario to create a vocabulary in sign language for representing scientific concepts while offering support for the integration of visually-oriented models and simulations, and written Portuguese in educational activities.

Key words: qualitative models, deaf, science education

1. Introduction

The Brazilian educational system is nowadays faced with the legal determination of promoting the education of deaf students along with hearing students in the so-called inclusive classrooms. In this context, it is important to understand the requirements for a successful inclusion of the deaf. Previous work [4; 6] has shown that QR models [7] are powerful tools for the education of deaf students, as they have interesting features for accomplishing this task: they articulate knowledge about different physical and social systems in conceptual models, presented with a graphical interface. A concise vocabulary is used to describe the phenomena represented in the models, and a restrict set of modeling primitives is enough to represent a wide class of scientific concepts. Finally, explicit representation of causal relations makes it is possible to ground predictions and explanations about the system behavior. In this context, the present work seeks to answer the following question: *What are the requirements to bring qualitative models into the classroom as useful tools for science education of deaf students?*

2. Sign language representation of QR models

Education is a well established area of application for QR models (Bredeweg and Forbus, 2003). This work explores these models as a tool for acquiring scientific concepts, improvement of linguistic skills and of inferential reasoning, already worked out with deaf students (Lima-Salles *et al.*, 2004; Salles *et al.*, 2005). Two qualitative models were used, 'tree and shade', already used and validated in (Lima-Salles *et al.*, 2004), and 'global warming', created to be the testbed for this study. The models were built in the QR engine Garp3 (Bredeweg *et al.*, 2006), following the Qualitative Process Theory (Forbus, 1984).

The causality chain shown in Figure 1 reads as follows. With investments, industry produces residues, including greenhouse gases. Besides that, in order to develop agricultural activities, farmers remove natural forest and burn residues of biomass, also releasing greenhouse gases. Both processes positively influence the Gross Domestic Product (GDP), and pollutant concentration influences the Earth temperature. Above a certain threshold, a positive influence establishes

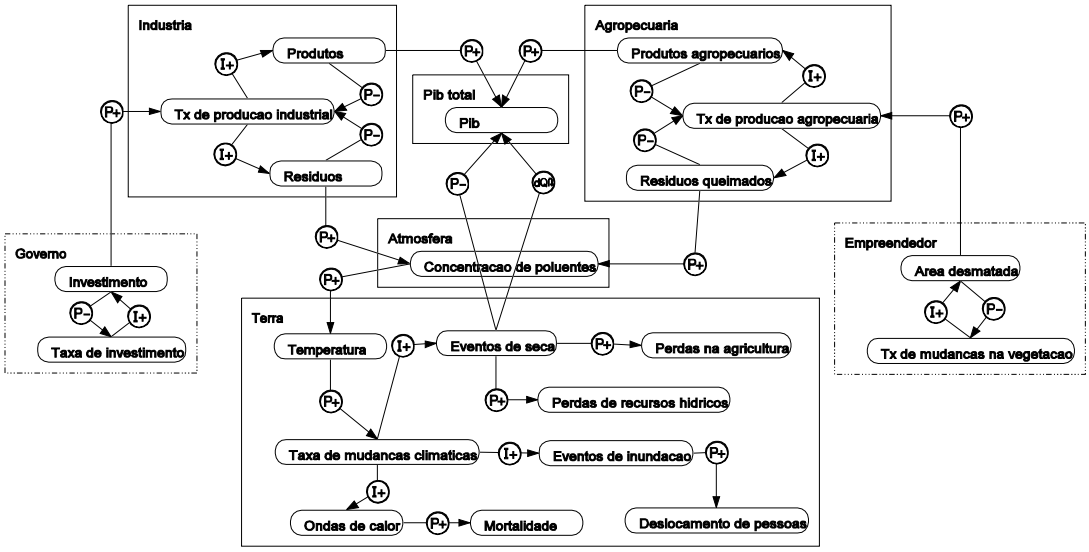

Figure 1. Causal model obtained in a simulation with the 'global warming' model.

a causal link between temperature and climate change rate, triggering the climate change process. The results include events of drought, flood and heat waves, which in turn cause, respectively, losses in agriculture and water resources, population displacement and human mortality. It is assumed that events of drought have a negative influence on GDP. Lack of scientific vocabulary in LIBRAS render difficult the development and understanding concepts by deaf students. This paper proposes a procedure for creating a set of signs to represent scientific concepts based on reusable QR modeling primitives. Creating signs is a complex process, and has to be carried out by the deaf community. First, a deep understanding of the topic to be represented is required. Such understanding has to be achieved at the community level, because a single person cannot impose to the community a sign for a (scientific) concept. In the work described here, a study group of 6 undergraduate deaf students first acquired understanding of models and modeling primitives, and subsequently created the signs. The study group produced a glossary of 32 lexical items in LIBRAS with terms used in qualitative models. Besides that, assignments for the models were created in a collaborative work carried out by the researchers and 8 secondary school teachers during a course on science education.

3. Model and sign validation

The 'global warming' model was conceptually and operationally validated by an expert, 8 secondary school teachers and 4 deaf undergraduate students. The expert concluded that the representation of causality in the model is acceptable, on the basis of (scientific) knowledge available (Rykiel, 1995). The teachers recognized its potential for the development of cognitive competences and abilities in science education. The deaf students were able to explain causal models, in written Portuguese, an evidence that they understood the concepts. Validation of the signs started with the presentation of modeling primitives and models to 17 deaf undergraduate students. Next, answers to a questionnaire and suggestions were collected, with the study group closing the loop reviewing each sign. Models, glossary and assignments were compiled into a DVD to be distributed to schools. This material is unique, as it presents the models in LIBRAS and uses written Portuguese in the assignments dedicated to explore causal reasoning and written skills in Portuguese (Lima-Salles *et al*., 2004; Salles *et al.*, 2005). Ongoing work includes the application of the DVD into the classroom, with both deaf and hearing students. The vocabulary in LIBRAS will be expanded and used to describe new scientific concepts and models.

4. Discussion and final remarks

How to adequately handle QR models in order to have them brought into the classroom as useful tools for science education of deaf students? The answer can be summarized as follows: focus on bilingual education, which has the potential to fulfill the needs of both deaf and hearing students; create a vocabulary for expressing scientific concepts in sign language, following a procedure that includes the representation of recurrent categories of scientific concepts (so that the signs may be reused in different contexts) and the participation of the deaf community, teachers and experts; and produce didactic material based on qualitative models and in a visual pedagogy in which a diagrammatic approach is integrated with written texts in Portuguese to explore concept acquisition, and the development of language

skills and of logical reasoning. The didactic material produced in the project may become the basis for the creation of a community of practice of deaf and hearing students that learn scientific concepts with the support of QR models and modern AI technologies (cf. www.dynalearn.eu).

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