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Learning by modeling: an attractive approach to learning environmental systems knowledge for secondary school students

Isabella G. Sá, Adriano Souza, Luiz H. Wilhelms,
Pedro A. Costa e Silva and Paulo Salles

isabellagontijo@gmail.com, adrianobiozen@gmail.com,
luizh_bio@hotmail.com, pedrocostaesilva@hotmail.com, psalles@unb.br

Institute of Biological Sciences, University of Brasilia
Campus Darcy Ribeiro, Brasilia, 70.910-900, Brazil

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Abstract

Current trends in science education point out to the importance of knowledge construction by students through an active interaction with the learning environment. Modeling activities will become part of science education, and will contribute to the learners' scientific reasoning. While involved in modeling tasks, learners acquire an understanding of the concepts at hand by exploring, building, using and testing computer models. Qualitative conceptual modeling has a great potential to support the learning by modeling approach as it provides a compact set of modeling elements, a formal language based on explicit representation of causality combined with mathematical foundations and the possibility of expressing heterogeneous, incomplete or uncertain knowledge and still run simulations to express the dynamics of (physical, biological, social etc.) systems without using numerical data.

The work described in this paper aims to present the results of an evaluation study of DynaLearn, a learning environment that combines qualitative reasoning, virtual pedagogical agents and semantic ontology (www.dynalearn.eu). This software is intended to be used primarily by secondary school and undergraduate students in a learning by modeling context, exploring a curriculum on environmental science, and, for the present study, principles of conservation biology.

The evaluation work was conducted in a public secondary school where 21 second year students, 15 to 17 years old, participate in a workshop on conducted by the authors of this paper. The workshop lasted 18 hours during which expositive dialogued lectures, discussion about relevant topics based on selected texts, and modeling activities were performed. The software DynaLearn (DL) was used as a learning workbench for the students to model knowledge about dynamic systems and, this way, to understand concepts and principles of conservation biology and their implications. DL presents a graphical interface where it is possible to access six different modeling environments, called Learning Spaces (LS), varying the quantity and types of model ingredients available for modeling activities. The most basic Learning Space

(LS1) allows for building conceptual maps and the most complete or complex Learning Space (LS6), to build generic and reusable models. During the workshop the students were asked to inspect, create and simulate qualitative models about fragmentation and devastation of the Cerrado biome due to agricultural expansion in LS1 (concept map) and LS2 (basic causal model); deforestation in LS3 (basic causal model with state graph); and main factors of biodiversity loss in Learning Space 4 (Causal differentiation model). To evaluate their experience with DL and modeling and reasoning about the issues explored in the workshop, two questionnaires were applied after the modeling activities and answered by 11 students.

The students were able to build models about the subjects discussed in class. Initially they expressed their understanding of the system in concept maps (LS1), including much more details than they did in LS2 and LS3. In doing so, they were developing the capacity of focusing on relevant aspects of the system to model. It was observed also that the students were able to correctly express causal relations between the objects and the variables in LS2 and LS3 and to correctly identify positive and negative influences.

Overall the students reported that the modeling activity was a motivating task, and agreed with the idea that modeling is an interesting approach both for teaching and learning. For some students, conceptual modeling is a totally new approach. Moreover, it was appointed by the students that this type of activity encourages a new way of thinking about the behavior of the ecological and environmental systems: “the software is really impressive, I could see problems our society is facing in a different way”.

Students reported no major difficulties in the tasks of identifying and extracting key information from relevant texts of reference used for the model development. Also, in general they agreed that, having built models, it was easier for them to express the same concepts in written texts.

The students did not indicate great difficulty in understanding and in describing the structure and behavior of the system when transposing knowledge expressed in concept maps into basic causal models. We notice, however, greater difficulty in understanding of the differences between direct influences and qualitative proportionalities, causal dependencies that respectively represent processes, the initial cause of changes in the system, and the modeling element used to propagate the effects of processes.

Asked about the course and the experience of using the software, the students considered very interesting the learning activities and showed a favourable opinion towards DL. One of the students said “I liked everything a lot, DynaLearn is a new way of learning; it was a little complicated in the beginning, but as time pass by our understanding is improved by the practice”.

After exploring problems related to biodiversity conservation in DL, students said they understand these topics much better, demonstrating greater interest on the potential of DL in the learning process: “I found this new software very interesting, because I think it would help very much learning in classroom; it is something different, and as a general rule, different things call our attention”.

Students agreed that modeling with the DL software opened up new ways of thinking about the natural systems. This argument can be found in statements like “What I found more interesting is that, after we establish some relations, it ‘thinks’ for us!” Another student “liked that it is possible

to better organize the knowledge and run simulations starting from some influences and quantities".

Thus, it seems that the software has promoted stronger ties between students and the subject matter, which facilitated and motivated them to participate in the activities proposed by the researchers, thereby learning the objects of knowledge, and hopefully developing scientific reasoning skills about the behavior of dynamic systems.

These results support the idea that learning by modeling may change the way students interact with their environment, possibly applying knowledge acquired at school and assuming a pro-active attitude towards their reality. As mentioned by one student: "Now all the polemic issues I see on the news, I feel like doing a model, even if mentally, pointing out which are the entities, quantities, causal relations… Anyway, it was very helpful!"

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