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How can we increase causal and structural system understanding in environmental science education? First evaluation results of a conceptual modelling software (DynaLearn) in Austria

Michaela Poppe (1), Andreas Zitek (1), Michael Stelzhammer (1), Bert Bredeweg (2), and Susanne Muhar (1)
(1) Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources and Life Sciences, BOKU Vienna, Austria (michaela.poppe@boku.ac.at), (2) Informatics Institute, University of Amsterdam, The Netherlands

The results of the last worldwide evaluation of 15-year-old school pupils' scholastic performance (Programme for International Student Assessment - PISA) showed that only an average of 1,1 % of young people across OECD countries performed excellent in science understanding (http://www.pisa.oecd.org). Students at the highest Level 6 can use scientific knowledge and develop arguments in support of recommendations and decisions that centre on personal, social or global situations. The OECD average is stated at Level 3, where students can identify clearly described scientific issues in a range of contexts. Nevertheless those students cannot clearly and consistently demonstrate advanced scientific thinking and reasoning.

The aim of the DynaLearn project (http://www.dynalearn.eu) is to develop an engaging, interactive, hierarchically structured learning environment able to capture and simulate causal relationships across disciplines and scales based on qualitative information. The evaluation of the prototype of the software represents an important part of the project that should deliver new insights in the efficiency of the features of DynaLearn to contribute to an effective, engaging and self-directed learning. Based on Qualitative Reasoning, the software is organized in six Learning Spaces (LSs) with increasing complexity including concept maps (LS1), basic causal models (LS2), basic causal models with state graph (LS3), differentiated causal models with rates and state variables (LS4) and the possibility to include conditional knowledge (LS5) and assumptions under which a certain system behaviour might be occurring (LS6). These LSs allow students to explore environmental topics at different levels of complexity taking an interdisciplinary viewpoint.

First evaluations were carried out in Austria at a secondary technical high school (i:HTL) and at the University of Natural Resources and Life Sciences (BOKU) with 31 students in total. Besides testing the effect of the modelling activity on content and structure of the domain knowledge, another important target of these pilot evaluations was to get feedback on usability and problems learners encounter with the software, supporting further development of software features such as 'Basic help', 'Diagnostic feedback', 'Recommendations', 'bug repair', etc.
Evaluation instruments used in the different settings included: videotaping of the modelling activities and students' questions, pre- and post-tests to evaluate changes in students' conceptual understanding, motivation questionnaires to get an impression of what students liked or disliked, and a final subject matter content test. Textual data were analysed with Atlas.ti software, Video recordings by Transana software. We hypothesized that working with DynaLearn would increase students' causal and structural understanding of environmental issues.

In both settings pre- and post-tests analyses showed a significant increase in the use of causal relationships as well as a significant increase of the abstraction level of representing knowledge in the post-tests. The answers in the motivation questionnaires proved that students 'highly' liked the model-based learning activity. However, the whole modelling approach was not considered as being very easy or self-explanatory. This will be improved by next software versions with the integration of further features such as Basic Help or Virtual Characters, which interact with the learners.

An understanding of science and technology is central to young people's preparedness for life in modern society. The first evaluation results of the DynaLearn software showed that students increased their system understanding and ability to represent knowledge in a more causal and abstract manner even after short modelling sessions. The results of the motivation questionnaires and the analyses of the videotaping clearly identify the potential of the software to be used in different fields of science education.