How can we cope with the complexity of the environment?

A "learning by modelling" approach using qualitative reasoning for developing causal models and simulations with focus on sustainable river catchment management.

Michaela Poppe (1), Andreas Zitek (1), Michael Stelzhammer (1), Paulo Salles (2), Bert Bredeweg (3) and Susanne Muhar (1)

(1) Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources and Applied Life Sciences, Vienna, Austria (michaela.poppe@boku.ac.at), (2) Institute of Biological Sciences, University of Brasilia, Brasilia, Brazil, (3) Informatics Institute, University of Amsterdam, Amsterdam, The Netherlands

Introduction

The education system needs strategies to attract future scientists and practitioners. There is an alarming decline in the number of students choosing science subjects. Reasons for this include the perceived complexity and the lack of effective cognitive tools that enable learners to acquire the expertise in a way that fits its qualitative nature.

Interactive qualitative knowledge models

The DynaLearn project utilises a "Learning by modelling" approach to deliver an individualised and engaging cognitive tool for acquiring conceptual knowledge. The modelling approach is based on qualitative reasoning, a research area within artificial intelligence, and allows for capturing and simulating qualitative systems knowledge (Forbus, 1984). Educational activities within the DynaLearn software address topics at different levels of complexity (Fig. 1), depending on the educational goals and settings (Bredeweg et al., 2009).

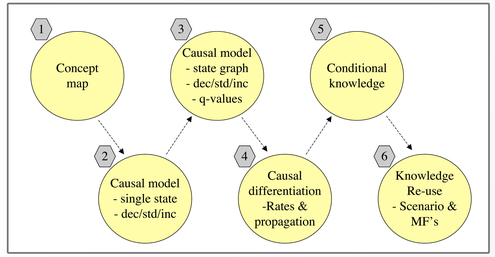

Fig. 1: Use levels 1 - 6 of the DynaLearn software.

DynaLearn uses virtual characters in the learning environment as agents for engaging and motivating the students during their modelling exercise. The DynaLearn software represents an interactive learning environment in which learners are in control of their learning activities. The software is able to coach them individually based on their current progress, their knowledge needs and learning goals.

Model on sustainable river catchment management

Within the project 70 expert models on different environmental issues covering seven core topics will be delivered. Within the topic "Land and Water Use" the Institute of Hydrobiology and Aquatic Ecosystem Management has developed a model on Sustainable River Catchment Management.

A sustainable, catchment-wide management of riverine landscapes is needed and stated by water right acts, e.g. the European Water Framework and Floods Directive. This interdisciplinary approach needs the integration of natural riverine processes, flood protection, resource management, landscape planning, and social and political aspects to achieve a sustainable development (Zitek et al., 2009).

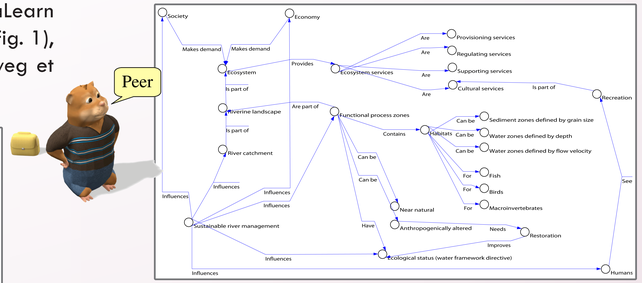

Fig. 2: Use level 1 (concept map).

The model integrates different ecosystem services of riverine landscapes and shows the multifunctionality of riverine systems with focus on ecological and recreational aspects (Fig. 2). The lack of attractive riverine sites led to the situation that recreational use concentrates in ecologically sensitive or restored areas, resulting in management conflicts (Fig. 3). An integrated management approach is needed to combine both social and ecological requirements (Fig. 4-6; Chiari, 2010).

Usability in the classroom

The model is used to support activities of students at the University as well as at High School within the DynaLearn Software to promote scientific culture in the secondary education system.

Model fragments allow learners to re-use parts of the existing model at different levels of complexity.

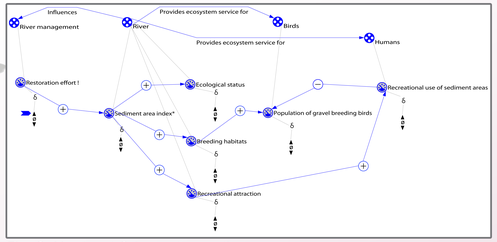

Fig. 3: Use level 2 (causal model).

But learners can also construct their own conceptual system knowledge, either individually or in a collaborative setting, using the model as a reference for comparisons of their own understanding.

Of special interest for the DynaLearn project is the intended development of interdisciplinary and social skills like cooperative working, cross-linked thinking, problem solving, decision-making, and the identification of the conflicts between environment, economy, legislation, science, technology, and society. A comprehensive evaluation of the DynaLearn software is part of the project.

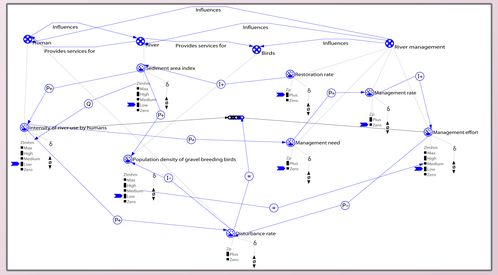

Fig. 4: Use level 4 (causal differentiation).

First evaluations with two students working for three days with use levels 1, 2 and 4 of DynaLearn were conducted between April 19th and 21st 2010 at a technical secondary school (IHTL) in Styria, Austria. The aim of the work was to identify effects of wind energy production on fish populations in rivers. Evaluations included video taping, pre- and post tests as well as a motivation questionnaire. The evaluation results provide an important first feedback on usability and problems learners encounter with the software.

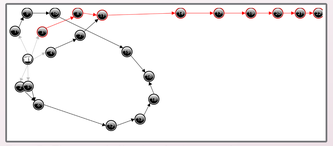

Fig. 5: The model's simulation path.

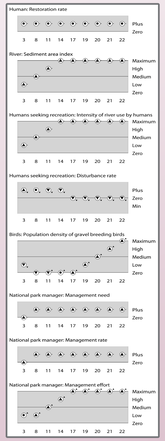

Fig. 6: The model's value history.

Preliminary evaluation results

Comparing pre- and post test results, Students' view of wind energy production and the effects on the environment became clearer, with increasing causality and conceptual understanding.

Both students were highly engaged and motivated by the activities with Dynalearn to develop their own viewpoints and hypotheses. They also got very interested in different fields of studies available at BOKU, clearly proving that the activities in the software increased their interest in environmental science, which is one of the defined targets of the DynaLearn project - to attract more students towards environmental science. But the use of Dynalearn represents also a challenge for teachers. Teachers have to define clearly which content and learning goals are associated and delivered best by which use level of DynaLearn. They have to rethink the methodological approach to convey knowledge to students.

But if concepts and teaching goals get defined more precisely the DynaLearn approach is likely to enable students to understand complex environmental systems better and faster.

References

Bredeweg, B. et al. (2009). *DynaLearn - Engaging and Informed Tools for Learning Conceptual System Knowledge*. Cognitive and Metacognitive Educational Systems (MCES2009).

Forbus, K.D. (1984). *Qualitative process theory*. Artificial Intelligence, Vol. 24, 85-168.

Zitek, A. et al. (2009). *Evaluating the potential of qualitative reasoning models to contribute to sustainable catchment management*. Ecological informatics 4, pp. 381-395.

Chiari, S. (2010). *Raumbedarf für multifunktionale Flusslandschaften* (Future Options for the Development of Riverine Landscapes - space requirements for multifunctionality). phD Thesis.

This work is co-funded by the EC within FP7, Project no. 231526, http://www.DynaLearn.eu