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First evaluations of the effect of the DynaLearn software on conceptual systems understanding of river catchments.

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Abstract

Environmental education in secondary schools in Europe increasingly fails to attract students, as environmental issues are perceived as too complex. Within the DynaLearn (DL) project, therefore an engaging, interactive, hierarchically structured learning environment able to capture and simulate causal relationships across disciplines and scales without the necessity of using numbers is being developed. The DL software provides means to integrate knowledge of different grain and extent without using numbers and is based on qualitative reasoning, a method that has been developed within artificial intelligence (AI). The software offers six Learning Spaces (LS) including concept maps (LS 1), basic causal models (LS 2), basic causal models with state graph (LS 3), differentiated causal models with rates and state variables (LS 4), differentiated causal models with the potential to define assumptions (LS 5) and finally generic reusable causal models based on a compositional modelling approach (LS 6). These LSs allow for a cross disciplinary exploration of practically every topic at different levels of complexity.

First evaluations of a prototype of the DL software were carried out in Austria at a secondary technical high school and at the University of Natural Resources and Life Sciences (BOKU), Vienna. An important target of this pilot evaluations was to get feedback on usability and problems learners encounter with the software, supporting the development of 'Basic help', 'Diagnostic feedback', 'Recommendations', 'bug repair', etc.

Videotaping was used to document the modelling activity and upcoming questions. Furthermore motivation questionnaires were used to get an impression, what the students liked and what they disliked and to collect further ideas to make the software more usable. Additionally domain specific pre- and post-tests were used to study the changes in student `s conceptual understanding after some learning activities with DL. A final exam at BOKU showed how students performed with regard to other content delivered in a more traditional way (held as frontal power point lectures). Atlas.ti software was used to annotate the pre- and post-tests following the grounded theory approach. Causal knowledge networks were developed and results were discussed along the prior hypotheses. Transcripts of the videos supporting software development were made using Transana 2.42 software.

At the secondary technical high school two students (one male and one female) were selected to participate the evaluation lasting for three days (09:00-13:30) with a final official presentation of their work at day four. The topic explored was the relationship between increased wind energy production and hydropower production and related environmental consequences. At each day a different learning space was introduced (LS 1, LS 2 and LS 4). The hypothesis for the pre- and post-test was, that there would be a significant increase in domain specific concepts identified, a significant increase in causal relations between concepts and an increase in graphical and abstract means to express relationships.

At the BOKU University 29 students (17 male, 12 female, 22-39 years old) participated the evaluation lasting for one afternoon (12:00-17:00). Models dealing with drivers and effects of river channelization on abiotic and biotic features of riverine landscapes were developed at three learning spaces (LS 1, LS 2 and LS 4). During pre- and post-test students were asked to describe with paper and pencil what could be seen at a series of four pictures showing the degradation and restoration of riverine landscape. The hypothesis was that the descriptions will be more abstract and causal in the post-test with an increased use of verbal and graphical causal relations. Because of the high level of the students` prior knowledge, an absolute increase in new concepts identified was not expected.

In general, the first evaluation results yielded very positive feedback of students with regard to the way learning content is delivered using the DL software, highlighting causal relationships and allowing for the creation of scenarios. Furthermore using the DL software as means for learning was experienced as very interesting and it was rated as very highly useful to be used in other disciplines. LS 1 (concept map) was recognized as an important pilot step for structuring the topic under exploration. In LS 2 especially the students at the secondary high school developed very personal viewpoints of the system under study. This was recognized as a very engaging feature helping to integrate prior knowledge into new content. LS 4 (detailed causal model) was liked most at the secondary technical high school due to its potential for a more realistic representation of real world systems, whereas LS 2 was most liked at the university, which can be explained by the limited time available to explore this LS.

In both situations, the use of DL software yielded significant effects on learning and causal understanding. More specifically, DL activities at the university level contributed to a significant decrease in words used for describing a phenomenon, and a significant increase in the level of abstraction of knowledge with an increase of using graphical causal relations. As expected, the number of identified concepts was not increasing, but slightly decreasing, which could be interpreted as the development of a focus towards the topic that has been explored.

At the secondary high school, based on a lower level of prior content related knowledge, the number of words used to describe a phenomenon, and the number of related concepts identified significantly increased from pre- to post-tests. Furthermore the use of verbal causal expressions increased significantly; graphical ways to express causal relations were only used sporadically.

Summarizing, different effects of DL activities were found during different evaluation situations. leading to the following hypotheses: If factual knowledge *increases***,** words and concepts might *increase* (new factual learning), if focus *increases,* numbers of words and concepts are expected to *decrease* and if causal and structural understanding *increase* the use of causal notations *(*graphical and verbal) might *increase* (structural and causal learning). Further evaluations will prove the consistency of these findings.

The first pilot evaluations helped to identify the potential for improving the usability of the software and the potential of the presented learning by modelling approach to contribute to a better environmental education.