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A Qualitative Reasoning–based Curriculum for learning about Sustainable Development

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Qualitative Reasoning (QR) has many qualities making it a useful ontology for education about system dynamics (Bredeweg and Forbus 2003). We implemented an online curriculum for learning about sustainable development using QR in Moodle, an online course management system (http://www.moodle.org). This curriculum is centred on qualitative reasoning models that explore sustainable development situations in a five case studies (Bredeweg et al. 2007), in addition to other models that explore specific sustainability issues. Each model is implemented using the QR model-building and inspeciting workbench, Garp3 (Bredeweg et al. 2006). The "lesson" activity in Moodle is used to create a series of questions that guide learners stepwise through different scenarios for each model. Additionally, the "Glossary" resource tool in Moodle is used to provide information that helps learners with help tips and definitions of SD and QR terms. Web pages in Moodle are used to present background information and suggest themes and learning routes for learners to explore the content of the curriculum.

We evaluated the structure of the Lesson activities for one of the modelled scenarios from one of the SD case studies. Each Lesson for each scenario is structured as follows:

1. background about the case study;
2. introduction and learning goals for the scenario;
3. exploration of the system structure;
4. exploration of causality of the system;
5. exploration of the dynamics of the system;
6. application to real world situation and to sustainable development.

Hence, questions are organised to move from structure to causality to dynamics to evaluation, while also achieving the six levels of cognitive ability described in Bloom's Taxonomy (namely: knowledge, comprehension, application, analysis, synthesis, and evaluation; Anderson et al. 2001). Each question is accompanied by a hint link, which instructs the learner how to interact with the model in Garp3 to discover the answer to the question. The Moodle tool collects learners' typed answers to the questions and reports them to the instructor (if desired). Before moving on to the next question, learners are able to compare their answer with an answer provided by the instructor. This allows learners to assess whether they have understood the intended content before moving on to higher-level questions. Specific questions for the evaluated lesson are provided below. Students were also asked about their impressions of the lesson format and using QR models to learn about sustainability.

Setting

We evaluated one of the lessons on the Curriculum page, as implemented in Moodle, with a university Botany class of 19 students. The class was composed of students ranging from second- to fourth-year Biology majors at Indiana University of Pennsylvania, USA. Students gave informed, written consent to participate in the study. None of the students had previously had a course in ecology or sustainable development. Some of the students had worked with concept maps (Cañas et al. 2003), but none had experience with qualitative reasoning models.

Methods

We presented the students with River Kamp Lesson 1 from the online curriculum. Although the curriculum has been designed with the idea in mind of learners working through the material on their own computer, this study investigated the use of the curriculum as standalone teaching material for gauging and expanding learners' understanding and stimulating discussion of problems related to sustainable development. In this case, only the teacher had a computer to show the materials as used the model as a demonstration tool. Hence we displayed the appropriate screen shots as if the students had run the model themselves, using a computer and video projector. Students were allowed to view the diagram and write their responses until it looked like most had finished writing. Then, the facilitator solicited student responses to the question. If it looked like they didn't understand how to answer the question, the presenter showed the appropriate help tip. After a few students had responded, the facilitator presented a prepared "correct" answer before moving on to the next question.

Results

Based on the written responses to questions in the lesson, all students made a good effort to answer the questions to the best of their ability, despite some technical difficulties with reading the displayed diagrams from across a large room.

Some students at first had difficulty grasping the meaning of some of the model diagrams during the first few questions. For example, instead of basing their answers on the diagram for question 2, several students based their answers on their background knowledge about natural catastrophes. This may have been due to their inability to access the help tips that would ordinarily be available if they were working on their own computers, which would guide the students in how to go about answering the question based on what is presented in the model. However, once they had the opportunity to hear responses of other students and the class went over the "correct" answer provided in the Lesson, most were able to catch up and were able to understand and appropriately respond to later questions. Students successfully used the diagrams to reason about a complex system involving causal feedback loops and multiple possible outcomes, including cyclic behaviour. For example, many students correctly predicted that multiple outcomes were possible and that the system would never stabilize (questions 6, 7, and 8). Finally, students responded for questions 9 and 10 that people could learn the government should institute policies that maintain sustainable actions even when community fear level is low. They also named several types of sustainable actions (e.g., maintaining natural ecosystems in the watershed to reduce flood levels) and unsustainable actions (e.g., building too close to the river or in areas that lie too low).

Students were also asked about their impressions of the lesson format and using QR models to learn about sustainability. Many students responded that they thought the simulation model provides useful support for learning about the behaviour of complex systems. Several students suggested more use of colour in the presentation, perhaps to hold their attention better or draw their attention to specific parts of the various diagrams. In fact, colour is used in systematic ways throughout the software to denote the ontological type or status of particular information elements in the diagram (i.e., actual values and derivatives are highlighted in red; for more on this issue, see Bredeweg et al. 2006). However, the students' comments indicate that there may be room for improvement in making the diagrams more attractive to this target group of users, or perhaps in including additional pictures or illustrations that bridge the gap between photographs and the diagrams as currently used. Again, when students interact with the models themselves on their own computers, this will probably be less of an issue because they will be moving screens

around, be able to view photographs from other pages if they want, and can access help tips to draw their attention to the focal points of each diagram.

Concluding remarks

Overall, students responded positively to the experience and several expressed interest (orally or in their written evaluations) in participating in future activities using the online curriculum. We are currently planning additional evaluation of the curriculum using this and other groups of students, where each student will have the opportunity to complete lessons on individual computer work stations.

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