The ScienceWare Modeler: A Learner-Centered Tool for Students Building Models

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ABSTRACT
Constructing and testing models is a complex task, but the process helps scientists develop a better understanding of natural systems. Similarly, we wish to support students building models, and so we have designed the ScienceWare Modeler with special learner-centered support for students to do scientific modeling and simulation. With the Modeler, students can easily construct dynamic models of scientific phenomena, and run simulations based on their models to verify and analyze the results. Students build their models using an easy-to-use object-oriented visual language – not traditional programming. This allows students to construct models quickly and easily, focusing their attention on the tasks of testing, analyzing, and re-examining their models, and the understanding on which these models are based.

KEYWORDS: Educational applications, Science applications, Modeling, Simulation, Multimedia, Learner-Centered Software Design

INTRODUCTION
Scientists build models to test theories and to develop a better understanding of complex systems [2]. We believe that students can similarly benefit from building models. This approach is consistent with constructionist theories of learning [4]; in order to build an internal, mental model of scientific phenomena, learners need to construct external representations of the phenomena as a system.

To develop that level of understanding, students need to engage in the activities of modeling, e.g., questioning, predicting, constructing, verifying. Just as technology is playing a key role in supporting professional scientists engaged in such activities, the ScienceWare Modeler has been designed to play a key role in supporting learners in learning and doing modeling.

The Modeler can be used to build a wide range of process flow models; for our preliminary classroom study we chose the domain of stream ecosystems. The Modeler is designed using a learner-centered approach [5], with scaffolding to address the specific needs of learners. Scaffolding [3] is an educational term that refers to providing support to learners while they engage in activities that are normally out of reach. We provide software-realized scaffolding to support learner’s needs regarding software tasks, tools, and interfaces:

Tasks
Learners need support for learning and understanding the task, which we designed into the Modeler by constraining the complexity of the tasks involved in building models. To build a model, students select from a set of high-level objects, define the factors (measurable quantities or characteristics associated with each object), and define the relationships between the factors. For example, in our example domain of stream ecosystem modeling, students might start with the stream object, define its factors “phosphate” and “quality,” and then define the relationship between them, all in a matter of minutes.

Tools
Learners need tools that adapt to their level of expertise, so the Modeler provides a range of ways to define relationships. Initially, relationships can be defined qualitatively by selecting descriptors in a sentence, e.g., “As stream phosphate increases, stream quality decreases by less and less” (Figure 1).

As the students’ skills increase, and their needs grow more sophisticated, they have the option of defining the
relationship more quantitatively, by entering data points into a table (Figure 2).

During a simulation, graphical meters provide real-time feedback of changing values. The objects in a model are displayed using photo-realistic graphics which can be imported by students. For our classroom study, the background graphic is a photograph of the actual stream the students studied. By using a photo of their stream we expect to make the task more concrete and authentic; meaningful, personal tasks are more motivating for students [1].

Learners also need an interface that guides them and encourages reflection about the task. To structure the task and guide the learner, we offer specific and useful options (e.g., the pull-down menus in Figure 1, tabular data entry in Figure 2), as opposed to only unrestricted text or equation entry. To encourage reflection, we elicit articulation from the students by providing an “explanation” field (e.g., Figure 2) where students can type in an explanation for each relationship they create.

**Interfaces**

Learners often need extra motivation to sustain interest in a task, and the interactivity and engaging personal graphics of the Modeler can help provide that motivation. Students run simulations to try out experiments using their models, such as exploring the impact of increased phosphate levels on overall stream quality (Figure 3).

To support different learning styles, these tools provide a variety of ways to visualize relationships. For example, given a qualitative definition, the software translates the text into a quantitative representation; e.g., “decreases by less and less” is interpreted as shown by the graph in Figure 1. This visualization of the text reinforces students’ understanding of how to “read” a graph.

The above relationships are termed “absolute,” in that the value of the affected factor is completely (“absolutely”) determined by the value of the causal factor. The Modeler also supports the definition of rate relationships which define feedback equations representing the rate of change of a factor. We similarly scaffold the definition of rate relationships by providing a qualitative representation, e.g., “At each time step, and for each mayfly, add mayfly rate of growth to mayfly count.”

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**REFERENCES**


