

What is learned from computer modeling? Modeling modeling knowledge in an experimental study

Sylvia P. van Borkulo, Wouter R. van Joolingen, University of Twente, Faculty of Behavioral Sciences,
Department of Instructional Technology, P.O. Box 217, 7500 AE Enschede, The Netherlands
Email: s.p.vanborkulo@utwente.nl, w.r.vanjoolingen@utwente.nl
Elwin R. Savelsbergh, Utrecht University, Utrecht, The Netherlands, e.r.savelsbergh@phys.uu.nl

Abstract: In this poster, we present an experiment in computer modeling that compares two rather contrasting conditions: traditional teaching and inquiry modeling. The modeling pre- and posttest operationalized the segments of a modeling knowledge framework. The experimental group of modelers performed significantly better than the traditional group on the complex items. Surprisingly, no differences were found for items about the creation of models. The implications for future research are discussed.

Introduction

Computer modeling is an emerging topic in secondary science education. The topic of modeling is relatively new in secondary education and not much is known about the specific learning outcomes and how the outcomes can be measured (Löhner, 2005; Spector, Christensen, Sioutine, & McCormack, 2001).

The essence of modeling is creating a simplified representation of reality to understand a situation. With the model one can do predictions and give explanations of phenomena. Computer modeling provides the possibility to run the model, perform experiments and evaluate the outcomes. Computer modeling tools such as STELLA (Steed, 1992), Model-It (Jackson, Stratford, Krajcik, & Soloway, 1996) or the modeling tool in Co-Lab (van Joolingen, de Jong, Lazonder, Savelsbergh, & Manlove, 2005) enable students to create models to represent their ideas about a domain, in terms of entities, variables and relations. When executing the model, the tool computes the values of the variables as they develop over time. This allows the learner to see the course of events predicted by the model.

A number of studies have investigated the processes of modeling as a learning activity (Hogan & Thomas, 2001; Löhner, van Joolingen, Savelsbergh, & van Hout-Wolters, 2005; Sins, Savelsbergh, & Van Joolingen, 2005), but less focus has been directed to the specific learning outcomes of modeling as a learning activity (Löhner, 2005). To be able to measure the specific types of knowledge that are built by learners as a result of a modeling activity, we developed a framework that gives a precise operationalization of the knowledge and skills involved (van Borkulo, van Joolingen, Savelsbergh, & de Jong, in press). In the following section, we will describe this framework. An experimental study is described and implications are discussed.

Modeling knowledge framework

The framework, in more detail described in van Borkulo, van Joolingen, Savelsbergh, & de Jong (in press), distinguishes three dimensions: 1) reasoning, 2) complexity, and 3) domain-specificity.

The reasoning dimension describes the specific reasoning processes that are involved in the process of learning activities in modeling. These reasoning processes can be derived from the process of scientific inquiry (de Jong, 2006; van Joolingen & de Jong, 1997; Klahr & Dunbar, 1988), where a mapping can be made from the processes of inquiry to reasoning processes involved with modeling. We distilled three types of reasoning related to experimenting with models. First, predicting and explaining using a model, which we call *applying* the rules of a model. Second, *evaluating* a model or data computed by simulating a model represents a search in experiment space and the mapping of its results to the predictions made by the model. Third, and finally, *creating* a model is building a new model or expanding an existing model, by adding or modifying variables and relations in the model. Creation processes represent a move in the hypothesis space.

The second dimension concerns the complexity of the model that is subject of the reasoning processes in the first dimension. A model has complexity due to its behavior, for example the occurrence of equilibrium, and due to its structure, for example the number of variables and relations, and the number of steps in a step by step reasoning. To cope with these aspects of complexity, we define *simple* as the smallest meaningful unit of a model, with one dependent variable and direct relations to that variable only, and *complex* as a larger chunk that contains indirect relations and maybe (multiple) loops and complex behavior, requiring more complex reasoning.

The third dimension concerns the influence of the domain in which the modeling takes place. Working with a model will be a mixture of general reasoning skills and stored domain-specific knowledge. Prior domain knowledge influences the reasoning processes, leads to reproducible knowledge, and may alter the complexity under the influence of preconceptions.

Research questions

In this paper, we will explore the differences in performance on a modeling test based on the modeling knowledge framework of two conditions: traditional teaching and inquiry modeling. The main difference between the two groups is the presence of a modeling tool and a simulation which will affect the type of reasoning. The traditional group is given the same textual information as the modeling group and mainly the same assignments, however they had to solve these assignments without simulation or modeling tool.

Method

Subjects were eleventh grade students from two schools. In total 74 subjects completed the experiment. The subjects in the modeling condition could use a simulation of the basic energy model of the earth, a modeling editor to create and run models, and graphs and tables to evaluate their data.

The experiment consisted of two sessions of each 200 minutes. Both the experimental and the control condition attended a first session in which modeling was introduced. After 150 minutes of instruction, all subjects completed a paper-and-pencil test in a fantasy domain about the harmony of the spheres (50 minutes). For the second session, the students were separated in two groups. The students in the experimental condition were given an elaborated modeling task about global warming for 150 minutes. The students in the control condition were given an assignment to write a small report on the causes of global warming for 150 minutes. After that, all subjects completed the black sphere test about global warming (50 minutes).

To gain insight in the differences in performance of the two conditions, we analyzed the variance of the mean scores on the black sphere test of subjects in the different conditions in the different segments of the framework with the fantasy test score as covariate.

Results

A significant difference was found in favor of the experimental condition on the complex item scores ($F(1, 72) = 8.780, p = .004$). More specifically, the experimental condition performed significantly better on both the complex items on reproducing domain knowledge ($F(1, 72) = 6.097, p = .016$) and the complex evaluate items ($F(1, 72) = 3.966, p = .050$). For the other segments in the framework no significant differences were found. No significant differences were found on the overall total score, though the experimental condition performed slightly better ($F(1, 72) = 2.972, p = .089$). No significant differences were found on the create segment.

Discussion

The aim of this study was to explore the differences in performance on a test that was based on a modeling knowledge framework (van Borkulo, van Joolingen, Savelsbergh, & de Jong, in press). In an experimental study, we compared two conditions: a group who followed a traditional approach in learning about global warming, and a group who followed an inquiry modeling approach.

Differences between the two conditions were found with respect to the complex items. The experimental condition performed significantly better on the overall complex items, on the complex evaluate items and on the complex reproduce items. The control condition performed slightly better on the simple reproduce items. On the remaining simple items they performed equally well.

We found no differences related to the creation of models. An explanation may be that the create items were too difficult for both groups. The modeling condition experienced creating models during the experiment, but each created model explicitly referred to a previous model. In the create items in the test, a model had to be created from a given context without any reference to previous experience.

In conclusion, the modeling test appears to be able to detect differences between a modeling group and a traditional group concerning complex items. It is worthwhile to further investigate the operationalization of the create items and the development of create skills in the instruction. Future research will need to focus on a connection between the two.

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