Open Student Models

Eshaa M. Alkhalifa
University of Bahrain, Bahrain

EVOLUTION OF OPEN STUDENT MODELS

When a student makes an error, the instructor wonders what possible misconception caused that error (Self, 1990) and attempts to correct it through altering the instruction method. Consequently, student models represent the system's assumptions of learner knowledge and preferences without giving any guarantees that this model accurately reflects any of the information it contains.

These models are utilized to present the right type of materials at the right point in time in the right presentation style (Fisher, 2001) in order to achieve optimal knowledge transfer. There are two main approaches followed when modeling student knowledge. The first attempts to delve into the cognitive workings of the student's mind and tries to best explain how the results could be obtained. Some of those who followed this approach are Martin and Vahn Lehn (1995), Langley, Wogulis, and Ohlsson (1990), Ikeda, Kono, and Mizoguchi (1993), among others. The second approach assumes the process that occurs between the "inputs" and "outputs" that occur in a "black box" scenario. The researchers who adopt this presumption attempt to formulate a mapping between the situation and student response to that situation. Some of those who are following this type of modeling include Webb, Cumming, Richard, and Yum (1991) and Webb and Kuzmycz (1996).

Those who follow the first approach are in a sense predicting possible causes for student behavior. In order to be able to check the accuracy of the student model in representing the student's cognitive characteristics, VanLehn and Niu (2001) conducted a study in sensitivity analysis. They found out that an intelligent interface is

Table 1. Classification of existing types of open student modelers

Classification of Model	**Dynamic Learner Modeling**	**Collaborative Student Model**	**Interactive Diagnosis**
Example Modeler	Tagus (Paiva and Self, 1995)	Mr Collins (Bull et al. (1995)	STYLE-OLM (Dimitova et al. (2000)
Communication Approach	Students can alter the model by typing prolog clauses or altering options	A student can "negotiate" with the system concerning the model through a special interface by selecting options from a menu.	Communication is organized as an exchange of speech acts where dialogue moves are extracted from a framework for analyzing education dialogues.
Level of Student Involvement	A student can alter the model	A student can negotiate with the system and have a different view than the system.	A student can only see the model and question it but not alter it.
Method of presentation	Not very user friendly because the model is a series of prolog clauses.	The model is shown as tables which contain domain rules so it is not very user friendly.	It has a graphical interface of the learner's belief network.

more likely to result in erroneous assumptions about student knowledge than a computer-aided instruction interface. They also found out that the accuracy of the model is strongly dependent on the inputs given to the modeler.

The fallibility of these modelers opened up a new avenue of research where students are allowed to see and learn from their models. This in short is an Open Student Model. Dimitrova, Self, and Brna (2000) indicate that when a student is allowed to join a discussion about his learner model, then he is engaged in the process of reflecting upon his knowledge and reconsidering the ideas and assumptions he has formed.

Misconceptions are consequently discovered by the learner and corrected. Existing approaches for involving the learner in the modeling process include open learner models (Paiva & Self, 1995), collaborative student models (Bull, Brna, & Pain, 1995), and interactive diagnosis (Dimitrova et al.,2000). These are listed in Table 1 along with their main features.

Allowing students to alter their own models may prove counter-productive to the learning process, while displaying the models in the three given forms also proved to lack user friendliness as students required detailed instructions teaching them how to interpret the first two of the system. The third was not evaluated.

The aim of having an open learner model is clearly to allow learners to reflect on their errors, and consequently the model should be presented in a form that would help achieve that goal.

MIRROR MODELER

The mirror modeler represents a novel open modeling approach where students are shown a list of the errors they are most likely to make in English. On the same page a student can instruct the system to mimic how he or she would solve several sample problems with those errors and compare that to how the ideal solutions are generated.

What differs here from all of the above modelers is that subjects are able to see their solution path from an external point of view as the system generates their errors. Students do not need any prior knowledge to aid them in comprehending the model, nor are they capable of altering the model so it resolves some of the issues that arose with the other types of modelers. This approach was evaluated through several experiments at the University of Bahrain (Alkhalifa, 2004; Alkhalifa & AlDallal, 2002).

The mirror modeler was tested as a part of an Internet-based interactive tutorial system set up to teach mathematical summations of the form:

$$\sum_{N=1}^{6} N = 1 + 2 + 3 + 4 + 5 + 6$$

Teaching can be in two directions: either giving students the Summation Notation and asking them to expand it giving the numbers on the right, or giving them the numbers on the right and asking them to return the Summation Notation. The second task is, of course, much more challenging than the first. The system is composed of a tutorial section, a practice test section, a test section, and a model comparison section.

The tutorial section is composed of two main parts: the first teaches them how to generate the series from the summation notation, while the second teaches them how to generate the notation from the series. The practice test section allows students to insert the notation they believe to be the answers and are shown the series generated from their inputs.

The test section examines their comprehension of the lessons given, and student responses are utilized by a rule-based expert system to diagnose the types of errors made. The errors are then listed in English to the student along with the probability of making that error represented as a percentage. Students can also observe the system while it generates the solutions that students are likely to give in response to different problems from the above while it is guided by the probabilities.

Results of the tests are represented in terms of the total number of errors made according to the summation operation type, as shown in Table 2. The summations shown are only examples of one of the two used, as numbers were altered as well as the order of the questions in order to prevent students from remembering the pretest questions when performing the post-test questions.

The effect of having the modeler as part of the system has brought the marks in both the division and multiplication type problems close to 100%. Conversely, the mirror modeler exhibited a damaging effect with respect to the more complex *power* operation, while the interactive tutorial maintained its ability to teach that form of series.

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