Open Student Models

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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 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

Table 1. Classification of existing types of open student modelers

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

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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:

$$N = 1 + 2 + 3 + 4 + 5 + 6$$

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

Table 2. Number of errors made by students classified according to summation operation type (additionally, the percentage of correct responses is given in brackets)

	No. of Students	Type of Test	Division 10 $\sum_{i=1}^{10} i/4$	Multiplication 11 12 3i i=2	Power 10 $i=1$ 2^{i}
Interactive Tutorial	21	Pre	56 (55.6%)	70 (44.4%)	54 (57.1%)
Interactive Tutorial	21	Post	14 (88.9%)	25 (80.2%)	28 (77.8%)
Tutorial + Mirror Modeler	12	Pre	6 (92%)	21 (70.8%)	10 (86.1%)
Tutorial + Mirror Modeler	12	Post	0 (100%)	1 (99%)	17 (76.4%)

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