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Some Unusual Open Learner Models

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Abstract. Open learner models to facilitate reflection are becoming more common in adaptive learning environments. There are a variety of approaches to presenting the learner model to the student, and for the student to interact with their open learner model, as the requirements for an open learner model will vary depending on the aims of the system. In this paper we extend existing approaches yet further, presenting three environments that offer: (i) haptic feedback on learner model data; (ii) a handheld open learner model to support collaboration amongst mobile learners; (iii) an approach which allows students to open their model to selected or to all peers and instructors, in anonymous or named form.

1. Introduction

Open learner models - learner models that are accessible to users - are becoming more common in adaptive learning environments, to afford learners greater control over their learning [1] and/or promote reflection [2]. The simplest and most common is a skill meter, displaying a learner's knowledge as a subset of expert knowledge in part-filled bars showing progress in different areas [3]; or the probability that a student knows a concept [4]. Extensions to this include: skill meters showing a user's knowledge level compared to the combined knowledge of other user groups [5]; knowledge level as a subset of material covered which is, in turn, a subset of expert knowledge [6]; knowledge level as a subset of material covered, as a subset of expert knowledge, and also the extent of misconceptions and size of topic [7]. More detailed presentations allow specific concepts, and sometimes specific misconceptions held, to be presented to the learner; and/or relationships between concepts to be shown. This may be in a variety of formats, such as a hierarchical tree structure [1]; conceptual graph [8]; externalisation of connections in a Bayesian model [9]; textual description of beliefs [2]. This variety of methods of viewing learner models illustrates that there is no agreed standard or best approach to opening them to users. In addition to the varied methods of presenting models, there are different ways of interacting with them. For example, a learner may simply be able to view their model [4,6]; they may be able to edit (i.e. directly change) the contents [1,7]; or undertake a process of negotiation where student and system come to an agreement over the most appropriate representations for the learner's current understanding [2,8]. The choice of viewing and interaction methods depends on the system aims. Most open learner models are for access only by the student modelled. However, some systems also open the model to peers [10] or instructors [11].

In line with these varied approaches, we now extend the range yet further. We present three open learner models that go beyond the approaches of existing examples, by offering unique methods of using or interacting with the model. The first provides haptic feedback on the learner model contents. The second is for use on a handheld computer, with a simple model that can be carried around routinely, to facilitate peer collaboration

should students come together opportunistically or for planned study sessions. The final example allows a learner to view the contents of their learner model, and also to open it to (selected or all) peers and (selected or all) instructors, either anonymously or with their names.

A survey of 44 university students found that students would be interested in using an open learner model. In particular, they want access to information about known topics or concepts (37 students), problems (40) and, perhaps most interesting because students often do not receive this information explicitly, identification of misconceptions (37) [12]. This was a survey-based investigation rather than an observation of system use, but similar results were later found amongst a group of 25 who had used an open open learner model that offers different views on the model data (extended version of [13]). 23 of the 25 found each of the above types of learner model information useful. In this paper we examine three quite different open learner modelling systems that model these attributes.

2. An Open Learner Model with Haptic Feedback

The haptic learner model is part of an environment that recommends material (slides, course notes, example code, exercises, discussion forum, further reading) on computer graphics according to the contents of the learner model constructed based on answers to multiple choice and item ordering questions. The learner model externalises to the user: concepts known, misconceptions as inferred from a misconceptions library, and difficulties inferred from incorrect responses that cannot be matched with specific misconceptions. Strength of evidence for knowledge and misconceptions is also given.

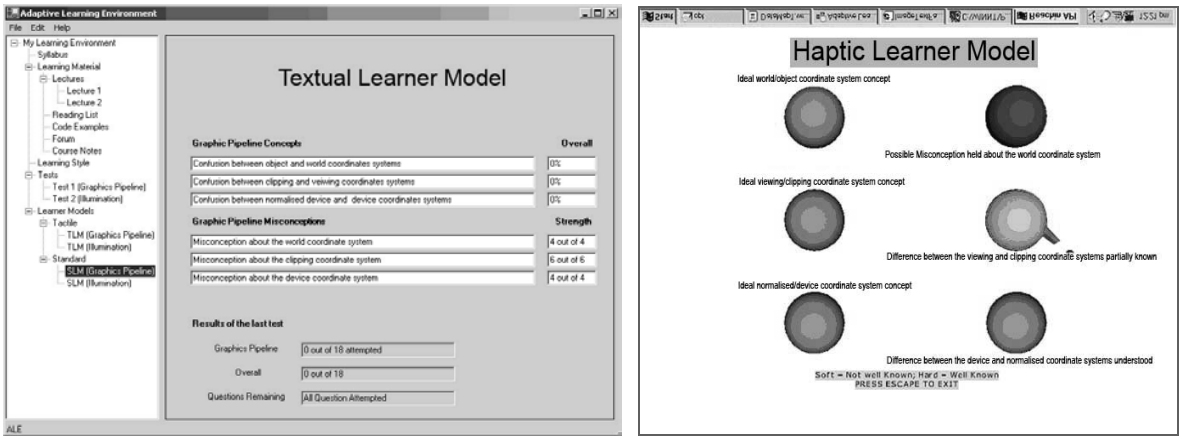

Fig. 1. A haptic learner model

There are two methods of accessing the model: a textual description (left of Fig. 1), and a version that combines text, graphics and haptic feedback (right of Fig. 1). Each allows access to the same information as described above. The textual model is straightforward, listing concepts and misconceptions, with a numerical indication of the strength of evidence for learner model entries. The haptic version displays a 3D scene with 'concept spheres' (with a textual description of the concept), which allow the learner to view and physically interact with their learner model using a haptic feedback device. The left side of the screen shows 'control spheres', indicating the state that learners are aiming for at their present stage of learning. The spheres to the right represent the learner's degree of understanding of the concepts on the left. Concepts are presented in shades of green - the brighter, the greater the level of understanding; and orange where the learner has difficulties. Misconceptions are red. As stated above, learners interact with their learner model using a haptic feedback device which provides force feedback. The haptic properties of the spheres are hard for

concepts that are known well, and softer for less well-known concepts. Misconceptions also use the property of magnetism (or stickiness) in order to highlight the problem by physically drawing the user towards the sphere, leaving misconceptions feeling 'soft and sticky'.

20 3rd/4th year undergraduates studying computer engineering or computer science took part in a lab-based study to discover whether students are able to understand a haptic learner model, and whether they find it useful. Post-interaction questionnaires/interviews revealed that, of the 20, 12 found the haptic model intuitive, understanding its purpose; and the same number found it a useful support for their learning, with 11 finding it a useful means of encouraging reflection. 10 students found the textual and haptic versions equally useful, but 8, a large minority, found the haptic model more helpful. Students were also asked to self-diagnose their preferred approaches to learning before using the system. Of these, 10 claimed physical interaction and touch were important (as opposed to hearing, reading, watching). However, only 4 of these 10 were amongst those who preferred the haptic version of the learner model. Thus it appears that additional haptic feedback on learner model data could be useful, including for some who would not expect physical interaction to be helpful. This accords with findings in the context of viewing the learner model, that students have differing preferred presentations that are not related to learning style [13].

3. An Open Learner Model to Support Collaboration on the Move

Our second example is part of an environment for use on a handheld computer when students have short periods of time that they could not otherwise use for individualised interactions, such as on public transport, waiting for friends at a restaurant, etc. A model of the learner's knowledge, difficulties and misconceptions is created during an interaction in which students answer multiple choice English grammar questions following tutoring. The learner model is open for learner viewing as a standard part of the interaction, to help learners become more aware of their progress. In contrast to the previous system, our mobile open learner model is quite simple, as displayed in Fig. 2. It uses standard skill meters to indicate overall understanding of topics, with additional textual descriptions. The aim is *not* to present learners with all the details of their problems, but rather, to encourage them to think about their knowledge and difficulties, and develop or improve the metacognitive skills of self-monitoring and self-evaluation. Thus, the textual information provided, focuses on their beliefs and not the correctness (or otherwise) of those beliefs. It is the responsibility of the student to compare their learner model to the domain content.

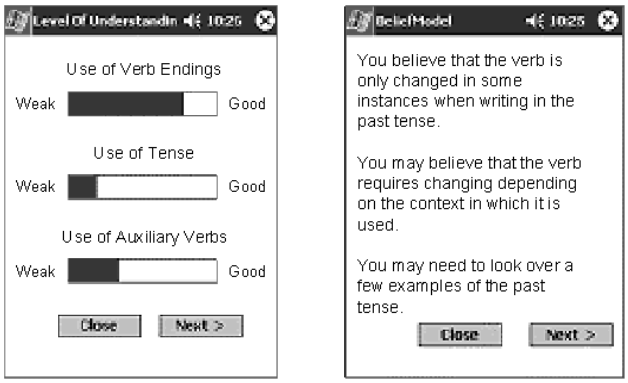

Fig. 2. A mobile learner model to support collaboration

It is intended that learners not only reflect on their learner model individually, but a major purpose of the system is that students should routinely carry their learner models with them on their handheld computers, in order that they may compare them to the models

of their friends if they meet opportunistically or for planned study sessions. Previous work suggested that students may engage in spontaneous peer tutoring if collaboratively examining their respective learner models [10]. This mobile version is intended to facilitate this process, as students do not have to meet in a fixed location where equipment is available, and do not necessarily have to schedule a learning session in advance.

The mobile learner model is part of an environment to teach English as a foreign language to advanced learners (e.g. university students in an English speaking country), who have difficulties with some aspects of grammar. Participants in the study described below were 8 Chinese MSc students at the University of Birmingham and 3 Punjabi-speaking students visiting Birmingham. The aim was simply to observe the way in which the system would be used in a semi-authentic setting. (The authenticity was necessarily limited by the presence of the experimenter and the need for video recordings for evaluation purposes.) There were no differences observed between the groups. The Chinese students arranged to meet for a meal at the home of one of the students, to combine a social occasion with a study session. The evaluation with the Punjabi students took place where one of them was staying, during a planned study session. Students joined together in pairs (in the case of the Punjabi students, a group of 3), and compared their learner models. They were given no instruction on how to approach discussion, or what to talk about. The following excerpt from one of the paired dialogues illustrates the kind of discussions that took place (transcribed from video recordings), when viewing the textual model descriptions:

S5:"Do you know what the past perfect continuous is? I am very confused, I do not understand. Is it used to talk about something that happened…well, I am not sure."

S3:"I think it is used to describe something that has happened before you do something else, so when you talk about two things. What score did you get for it?"

This illustrates that students are able to identify their areas of difficulty from their learner model, and will explain the grammar rules to each other. The final comment indicates that students were using their respective levels of performance shown by the skill meters, to decide which of them is more likely to be using a rule correctly, and hence able to explain it to the other. Other comments from the paired interactions include the following, further illustrating the common focus on correctness as portrayed in the learner model skill meters:

"I did not do so good in the past perfect. What did you get for that?"

"You do better in the past perfect, can you tell me what it is? I did not do well on that."

Students were willing to discuss their models. However, given that performance levels were available and seemed to be a focus of discussion, we would consider *not* providing such information (i.e. not using skill meters). Students would then have to think more about their beliefs to decide who may be best able to explain a rule in cases where their models differ (i.e. knowledge or specific problems rather than knowledge level). This would fit better with the aim of developing the skill of self-evaluation. It might result in a greater degree of reflection: in a context where information about level of performance was not given, students thought more carefully about their respective beliefs, and spontaneous peer tutoring was observed [10]. It would therefore be interesting to compare discussion and learning outcomes of students who have the skill meters and students who do not. A further issue to consider is how the absence of skill meters might affect individual use.

4. A Learner Model that can be Opened to Peers and Instructors

We now return to the desktop PC, with an open learner model showing knowledge level of C programming in skill meter form (as a series of filled and unfilled stars), and a corresponding textual description, constructed based on responses to multiple choice

questions (Fig. 3). A statement of misconceptions inferred from a misconceptions library is also presented. If the learner disagrees with the model, they can request a test to quickly update it. Students can open their model to peers and/or instructors, choosing for each individual whether to release their model anonymously or with their personal details. Peer models are accessed by clicking on a peer's name or model number (for models released anonymously). Note that some learners may access a peer model anonymously, while others have named access to the same model, and yet others have no access. Students can view group data of the distribution of knowledge/problems across all users.

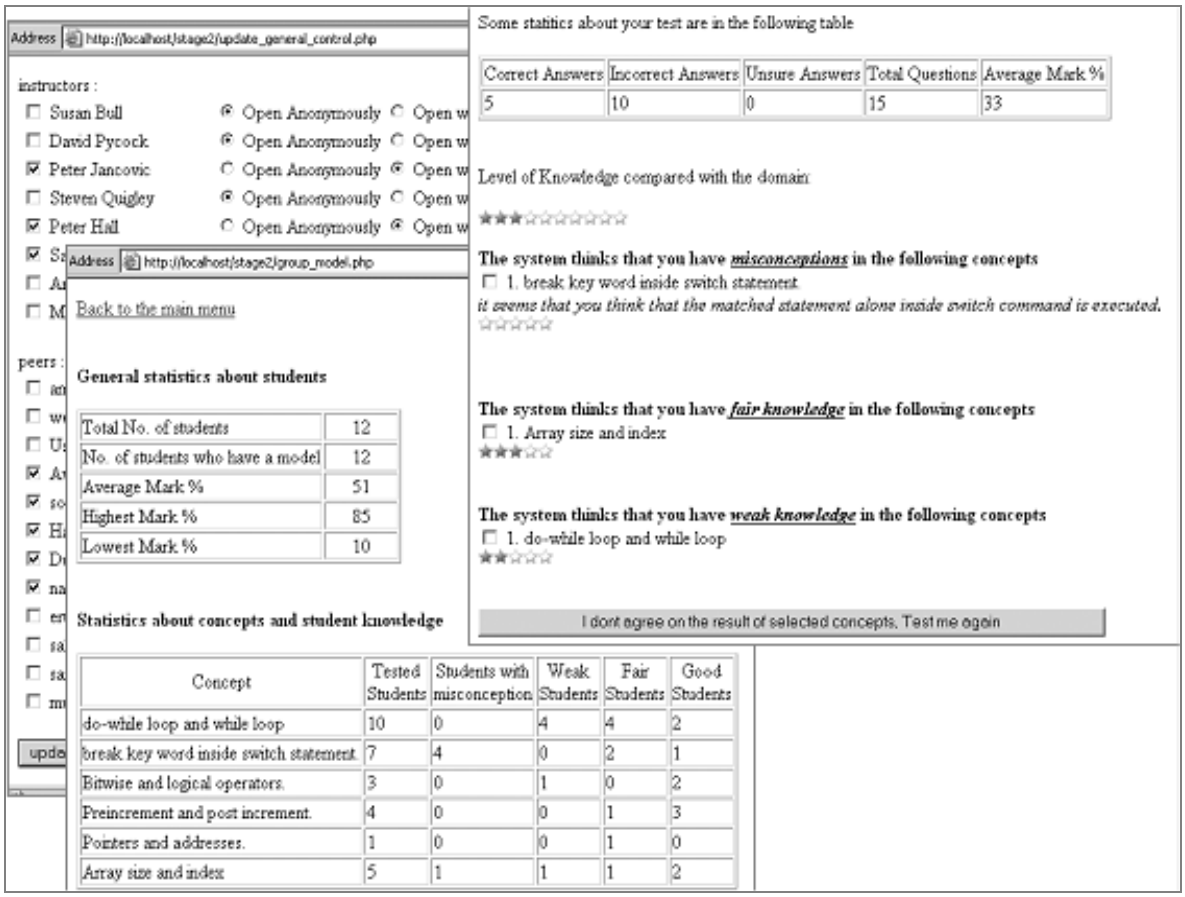

Fig. 3. A learner model open to students, peers and instructors

Table 1. Opening the learner model to others

	Open for Instructors					*Open for Peers*				
	None	All		Selected		None	All		Selected	
Student		anon	named	anon	named		anon	named	anon	named
S1		X						X		
S2					X					X
S3			X					X		
S4		X					X			
S5	X						X			
S6			X				X			
S7				X		X				
S8		X						X		
S9					X		X			
S10			X					X		
S11		X					X			
S12			X					X		
Total	1	4	4	1	2	1	5	5	0	1

12 MSc students in Electronic, Electrical and Computer Engineering took part in an initial lab study to investigate whether students would be willing to open their models to

others and, if so, whether they would do so named or anonymously. Results are in Table 1. Only 1 student chose not to open their model to instructors, and 1 to peers. These were different students in each case. 8 opened their learner model to all instructors, 4 of whom did so anonymously, and 4 named. 3 opened their model to selected instructors only - 1 anonymously and 2 named. 1 student opened their learner model only to selected peers. 10 students opened their model to all peers, 5 anonymously and 5 named. Those who opened their model anonymously to instructors did not necessarily choose to remain anonymous to peers, and those who allowed instructors to view their learner model with personal details did not necessarily allow peers to view their identifying data. This small-scale study has not allowed us to investigate possible patterns of opening the model over time - the aim at this initial stage was to determine whether students are willing to make their learner model data available to others, and whether they wish to view the models of peers. Usage suggests that providing a choice of how and to whom to open the learner model, is important. In a post-interaction questionnaire, 10 of the 12 students stated that being able to select between individuals was useful, and all 12 liked the anonymous/named distinction. 11 stated that they found their own learner model useful. 8 found the individual peer models useful, and 8 found the group model useful. Thus viewing their own learner model seemed to be useful for the majority, and peer models also appear helpful for many. Comparing questionnaire results to the usage data, the facility to make the choice of who should have access to their learner model seems important even for students who opened their model to everyone.

5. Discussion

The haptic learner model was designed for individual users who prefer physical interaction in learning to encourage their interest in the learner model, but it may also be perceived as useful by others. However, longer term use needs to be studied to determine the extent to which positive reactions are related to the novelty of the haptic approach. The other two systems are essentially individual environments with learner models that can also be viewed by other people. Learners who enjoy collaboration and the social side of learning may favour the mobile environment, which expects co-present peers. However, the collaborative phase is not essential, and the system could be used simply in situations where the learner is away from a desktop PC. The final example was designed specifically for a broader range of students - those who like to work individually, who may or may not wish to compare their learner model with models of peers; those who enjoy collaborative learning who may use the peer models to seek learning partners; or competitive learners who strive to outperform others, who may check their progress against peers, without interacting with those other students. While the above descriptions of learner types match some of the learner groups described by various learning style categorisations (of which there are many), we do not wish to prescribe certain interaction methods for different learners according to their learning style, until more is understood about the relationship between learning style and computer-based educational interactions, including methods of access to open learner models, as a clear relationship between the two cannot be assumed [see 13].

While the underlying representations in our three systems are quite similar, the information available to learners differs. The haptic model only names the concepts and misconceptions, with an indication of the strength of each (by visual or haptic properties), but does not give further detail. The mobile open learner model presents an overview of the extent of understanding, together with a textual description of beliefs, but without ascribing any level of correctness to the textual information. Thus students know their general level of ability or skill, but must themselves determine the specific details of what they know, or

what their problems may be. The model that can be opened to peers and instructors lists concepts known and specific misconceptions, and allows group data to be displayed, which can be compared to individual performance. Each of the open learner models was designed to fit the purpose for which it was created, which necessarily results in these differences.

While some previous findings suggest students may not use open learner models [14,15], results are more positive for studies where the open learner model was integrated into the interaction [2,8]. Initial evaluations of the systems in this paper have indicated that more unusual approaches to integrated open learner models may also be of benefit. However, it is not expected that each of the approaches will suit all learners. Adaptive learning environments came into being because of the recognition that learners are different, and the function of these systems is to adapt to individual differences. There is no reason to suppose that use of an open learner model is any different - students may differentially benefit from the existence of an open learner model, and also from the method of viewing, sharing and interacting with it. Our aim, then, is to further develop open learner models that are useful to sufficient numbers of learners to make this worthwhile. It is likely that this will often involve models that can be viewed or accessed in different ways, rather than the more common single learner model presentation in most current systems. It has been found that students have clear preferences for how to view their learner model [13]. The three systems in this paper illustrate this to some extent. The mobile learner model can be viewed as a skill meter overview or as a more detailed textual description of beliefs, though it is likely that learners will use both. (However, as noted above, we would consider removing the skill meters, as one of the aims of the environment is to develop the metacognitive skill of self-evaluation. The skill meters may stifle this in a collaborative setting.) Regardless of whether the skill meters are maintained, the main difference in usage will probably be in whether students use the model individually, or as part of a collaborative session. This is also true of the system that allows learners to open their model to others. With our small group, most students opened their learner model to all peers. In a recent study with 50 students, initial findings are that some learners open their models quite widely, while some prefer a more restricted focus amongst those they know well, or even an individual focus. Most students viewed the peer models positively, using them to find their relative position in the class and which topics are generally difficult. Some used them to seek collaborators, while some used them competitively, to try to outperform others [16]. The haptic model may be accessed differentially, either the textual or haptic version, since these show the same information.

The evaluations described in this paper are, of course, quite limited, and should be regarded only as a first step. Further work is required to answer questions such as:

- When the haptic learner model is no longer a novelty, will students continue to use it?
- Will a haptic learner model work best in a learning environment that uses haptic interaction in other areas, or can it be equally useful in an environment that otherwise uses no force-feedback?
- Will students really use their mobile learner models when they meet opportunistically, or might they be used only when collaborative learning sessions have been planned?
- Would removing the mobile skill meters result in more reflective discussion?
- Would removal of the skill meters be beneficial or detrimental to individual usage?
- To what extent will learners use the models of peers over an extended period?
- Will instructors really use the information about their students, or would other demands on their time make this unlikely in practice?
- Is there any difference in performance with different kinds of open learner model, or does the effect of the presentation or interaction method vary according to the individual's preferences? To what extent is this presentation or preference-specific?

There remain many issues to address before we may discover the real potential of such unusual open learner models, but initial results suggest that this research is worth pursuing.

6. Summary

There are many approaches to opening the learner model to the learner, and there is no agreed or best method for doing so. Requirements for open learner models are dependent on the aims of the systems in which the models are used. This paper has broadened the approaches to open learner modelling yet further, with three new examples. Early work has suggested that further investigation of extensions to existing open learner modelling approaches is worth-while, and it has been suggested that systems might benefit from allowing users to view and/or interact with their learner model in different ways.

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