Adaptive Navigation Support, Learner Control and Open Learner Models

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Abstract. We consider open learner models (OLM) with reference to adaptive navigation support and learner control. Our purpose is to assess the potential of a greater range of OLMs in adaptive educational hypermedia. We introduce five OLMs, discuss how these might be applied, and present learner reactions.

1. Introduction

Adaptive educational hypermedia (AEH) may take many forms. Traditional examples include adaptive presentation and adaptive link support [1],[2]. This may relate to selection or inclusion of content, or link highlighting/annotation to indicate currently recommended links [3]. User knowledge is held in a learner model (LM), typically inferred from browsing or test items, and used to personalise the interaction. Open learner models (OLM) 'open' the LM to the user. AEH sometimes releases some information about the learner's knowledge [4],[5], offering navigation support with link annotations as suggestions for appropriate pages according to the user's knowledge (e.g. a user can infer their knowledge of prerequisites for a topic from link annotations). Simple OLMs giving an overview of knowledge levels are also used [6]. OLMs may also have complex displays, e.g.: trees [7]; conceptual graphs [8]. Aims of OLMs include to: prompt reflection [9]; improve self-assessment [6]; provide accountability/responsibility in learning [7]. AEH already performs testing to inform the LM and offer guidance [5]. Linking other aspects of OLMs and AEH may provide additional navigation support while also prompting further reflection/self-assessment.

2. Open Learner Models and Adaptive Educational Hypermedia

We use 5 OLMs that allow learner control over the interaction, in common with the control users can typically take in AEH systems with adaptive navigation support [4].

Simple and detailed: OLMlets elicits learner knowledge using multiple choice questions. It has 5 simple views of the LM [10]. Fig. 1 shows two of these: the graph and skill meters. Users can use information about their knowledge level (medium shading) or misconceptions (dark shading) and misconception statements (e.g. "you may believe that you can leave factorisation with squared terms"), as a recommendation of where to navigate (here to questions/materials). Users can also see the knowledge they are currently expected to have, by comparing their LM to instructor expectations (shown in the skill meters). Some of these features are similar to navigation support in AEH. Flexi-OLM shows more detailed LMs. It uses multiple choice and short answer questions, and provides 7 LM views [11]. Fig. 1 shows a map and hierarchical tree, which could be applied in AEH as such relationships are often defined.

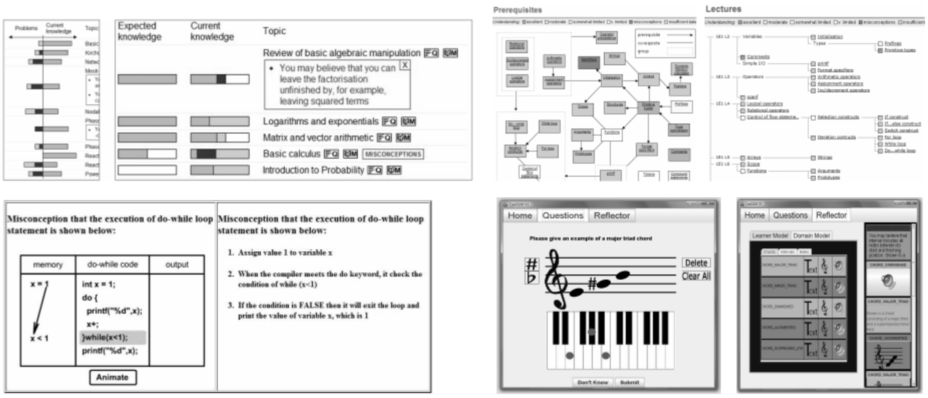

Fig. 1. *upper left* simple OLM views - graph and skill meters; *upper right* complex OLM views - prerequisites and lecture structure; *lower left* an animated OLM - animation and text; *lower right* a music OLM - inputting musical notes; text, music notation and audio OLM views.

Animated and audio: Some educational systems use materials in formats other than text or graphics, e.g. animation or audio [12],[13]. 2 other OLMs offering multiple views of the LM are AniMis, including animation; and musicaLM with audio. AniMis is built on top of OLMlets, so knowledge level is shown in the same way. Following 'misconceptions' links leads to misconceptions presented as text and animations (a programming example is in Fig. 1). In the animation, values are added to the left (memory) and right (output) columns as code is highlighted. Steps of a misconception are also given in text. Fig. 1 also shows how students input information in musicaLM: by music notation or keyboard. The LM is accessed in 3 forms: text description (e.g. "you may believe that whole tones are adjacent notes in the chromatic scale"); music notation, a natural way of referring to the music domain; audio, where the LM is presented by sound (notes). Domain and LM concepts (and misconceptions) recently accessed are displayed down the right side of the screen for easy comparison (text and music notation are shown; clicking on the sound icon replays audio).

Interactive: Some OLMs permit greater control over the LM such as allowing the user to scrutinise adaptations, increasing their understanding of the role of the model and enabling them to change their profile [14]. Learners may also edit their LM if it is inaccurate [5]. Although Flexi-OLM provides evidence for its beliefs, users can ignore this information and still change the LM if they wish. Editing the LM offers a quick way of updating it if the user can provide data that could not be predicted (e.g. recent learning from reading or a lecture). They may use links ignoring recommendations that no longer fit; or they may quickly update the LM allowing rapid re-adaptation. Editing the LM increases the user control that is important in many AEH applications, beyond the freedom to follow any link.

While learner control is considered important, it is suggested that if control of the LM is with learners, they may inaccurately assess their knowledge [15]. Although users may give information for modelling, they may be less comfortable with having full control [11]. More balanced control is offered by negotiated LMs: student and system agree on the LM contents through discussion - e.g. the user may challenge their LM. The system may provide evidence to support its views; it may offer a short test if the user does not accept the evidence; it may allow the user to give explanations (e.g. "I've forgotten"); etc. [8],[9]. Recent work has used a chatbot for negotiating the LM in CALMsystem [16], the final system used here. In an environment with an approach such as adaptive link support, where control is with the user, negotiating the LM or even simply discussing it, may be beneficial when the user does not understand why a link is recommended, or if they are unsure whether the LM is accurate.

Table 1. Open learner model preferences

		Agree		***Neutral***		***Disagree***	
1. Types of OLM students would use							
OLM to support navigation	(n=181)	78.5 %		20.5 %		1 %	
OLM to increase awareness of knowledge	(n=181)	82.5 %		17 %		0.5 %	
OLM to gain control over learning	(n=181)	53 %		40 %		7 %	
Overview presentation only	(n=181)	17 %		32 %		51 %	
Detailed presentation only	(n=181)	40 %		20 %		40 %	
Both overview and detailed presentation	(n=181)	64 %		32 %		4 %	
2. Understood OLM representations / trusted OLM							
OLMlets (understood / trusted)	(n=11)	10	9	1	1		1
Flexi-OLM (understood / trusted)	(n=9)	7	7	2	2		
AniMis (understood / trusted)	(n=10)	9	10	1			
musicaLM (understood / trusted)	(n=10)	10	8		2		
CALMsystem (understood / trusted)	(n=8)	8	6		1		2

181 university students who had used 2-5 OLMs, at least one throughout a term, completed a questionnaire. 8-11 used our 5 OLMs, interactions with each OLM lasting 90 mins. Table 1 shows that most of the 181 students wanted an OLM to support navigation. AEH often provides navigation support with link annotation. We suggest it may be useful if link adaptations also allow users to gauge their knowledge (in addition to the relevance of a link). This is achieved in ELM-ART, with a combination of link annotations indicating readiness to visit sections, and skill meters to show knowledge [5]. A little over 1/2 stated they would like greater control over learning, with only 7% responding negatively. While learner control and independence are seen as important by educators, not all students view it as critical. An advantage of adaptive navigation support is that control *is* with the user. For those who consider control over their learning to be important, additional features in the OLM may be a useful way of not only supporting decision-making, but also prompting reflection. This may also benefit those who had not considered their active role in learning. Learner control can also be achieved by interactive modelling. It may be worth considering allowing LM editing or negotiation: those who wish to inspect the model only, may still do so. AEH often has relatively simple indications of learner knowledge. Some users may find this less useful than detailed LM data, and many would prefer a combination. As most users of our 5 OLMs understood and trusted the LMs, there seem little grounds

at this stage to argue for any one approach (though some features may be useful in specific contexts). Of course, an attractive feature of AEH is its clarity. More complex OLMs may hamper this. Nevertheless, some combination of AEH and a range of OLM features seems worth considering, in particular: combining navigation support/knowledge awareness; sufficiently detailed LM data; and challenging LM representations. Investigations with a greater number of users will help to clarify this.

3. Summary

We have presented 5 OLMs to consider a greater range of OLMs in AEH - in particular for adaptive navigation support and learner control. We suggest various OLM features may be useful, especially a means of identifying knowledge; provision of more detailed information about the LM data; and a way to challenge the model.

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