Preferences in Multiple-View Open Learner Models

Susan Bull, Inderdip Gakhal, Daniel Grundy, Matthew Johnson,
Andrew Mabbott, and Jing Xu

Electronic, Electrical and Computer Engineering, University of Birmingham, U.K.

Abstract. Educational systems that model the user enable personalisation. Systems that open the model to the user to prompt reflection are increasingly common. These often offer a single view of the model. We introduce multiple-view open learner models, and show the varied preferences for model presentation.

1 Introduction

Adaptive learning environments create a model of a user's understanding inferred from their actions (e.g. problem solving, answers, navigation). Typically, the aim is to achieve an accurate learner model to enable personalisation. Such adaptation may include choice of material; tasks, exercises or difficulty of problems; method of presentation. The underlying model will often not be in a suitable form for learner scrutiny. However, it has been suggested that learner models be opened to the user they represent, to: promote reflection; give greater responsibility for decisions in learning; support navigation; encourage formative or self-assessment [1]. These are commonly referred to as 'open learner models' (OLM). Models have been presented in a variety of ways, from skill meter overviews ([2],[3],[4]) to structured views, including conceptual graphs [5], Bayesian networks [6] and hierarchical trees [7]. Thus an OLM, whether simple or complex, allows the user to view inferences about their knowledge in an *understandable form*. It has been found that users may attend to different model information depending on whether it is presented in a way they prefer [8]. We therefore investigate whether there may be different preferences for model view with six multiple-view OLMs, with different subject areas and different target users.

2 Six Multiple-View Open Learner Models

OLMs may be fully integrated into a learning environment or may be independent of a larger system with the aim of promoting metacognitive skills such as planning, reflection, self-monitoring; and facilitate learner independence. Here the learner maintains control over choices in their learning, completing tasks and accessing the model as required. They then undertake appropriate study away from the system according to the information in their OLM. Such models are termed 'independent OLMs'. We introduce systems of the latter type, where interactions aim to help the user understand their knowledge state so they can identify their learning needs for themselves. Fig. 1 shows the differences in the structure of the model views for each system.

M. Wolpers et al. (Eds.): EC-TEL 2010, LNCS 6383, pp. 476–481, 2010.

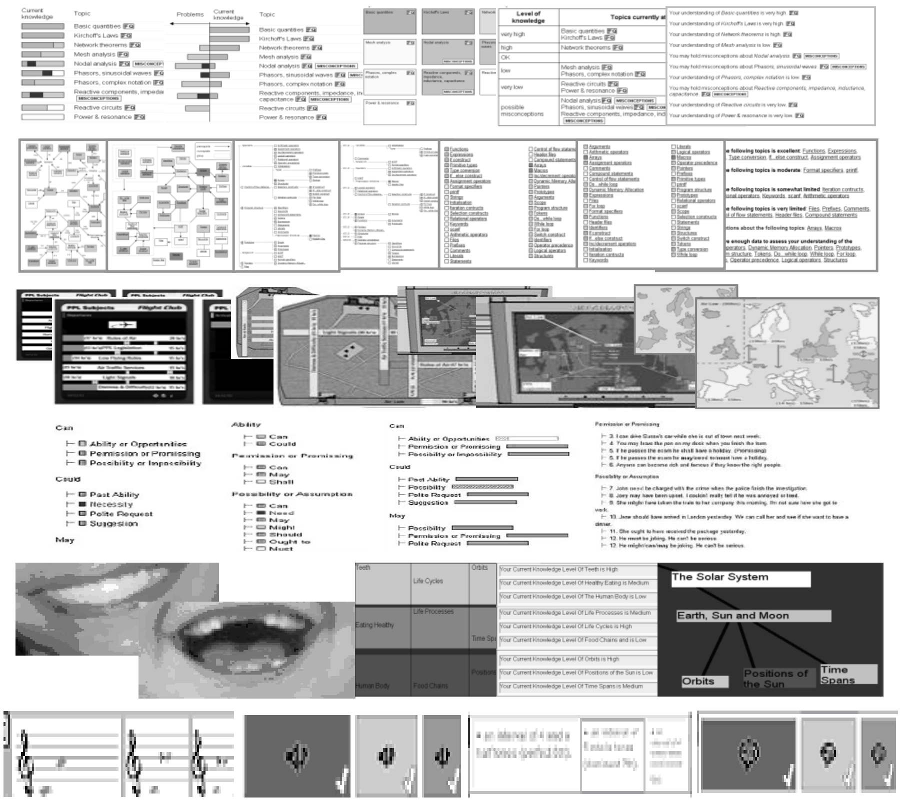

Fig. 1. OLM views: OLMlets, Flexi-OLM, Flight Club2, OLMLA, Point of View, MusicaLM

1. OLMlets is domain-independent, for easy adoption into a range of university courses. Use in most courses is voluntary, and 2/3 of students use it across courses in which it is available. Fig. 1 (top) shows the structure of the views: skill meters give knowledge level of topics, including extent of misconceptions; a similar graphical view, but with positive information about knowledge on one side of an axis, and negative information (not known, misconceptions) on the other; boxes around topic names with colour showing knowledge; table with knowledge in ranked order; text summary of knowledge. A statement of misconceptions can be obtained (e.g. "You may believe that resistance is reactive" in a 1^{st} year electrical circuits course). We use data from 22 courses, comprising 812 learner models. Most courses were 1 term.

2. *Flexi-OLM* (Fig. 1 row 2) was deployed for 2 terms in a university C programming course. 65 of the 135 students registered used Flexi-OLM. Given the more structured underlying model (possible because of a specific domain), most views are more complex than OLMlets. Each shows the same basic information (level of understanding by colour of nodes, descriptions of misconceptions - e.g. "you may believe that division of two integer values can give a floating point result"), but with some variation due to the nature of the specific views (e.g. information about relationships

between concepts). The detailed views are in the form of maps (concept and prerequisite relationships), and tree structures (hierarchy of related concepts and lecture structure). List views (ranked, alphabetical), and a ranked text summary, are simpler.

3. *Flight Club2* Trainees studying for their Private Pilot's Licence must complete 7 ground exams by independent learning alongside practical flight training. The content of ground examinations will often not match current practical training. Flight Club2 (Fig. 1 row 3) was designed to take advantage of the potential for OLMs to help users identify their learning needs. Each of the 4 OLM views has a simple (s) and detailed (d) presentation (an intermediate level of detail compared to OLMlets/Flexi-OLM). The simple views are first in each pair in Fig. 1; the more detailed give further breakdown. The first pair is skill meters. The meters move from the left departures board to the right arrivals board once knowledge has reached that required to pass the exam. The runway view is similar: runways fill with colour as knowledge increases, but the layout reflects the aerial view of an airport, with crosspoints relating to prerequisite knowledge. The radar view depicts knowledge by distance of aircraft from the airport (centre of screen). Aircraft move inside the airport perimeter once knowledge reaches an examinable standard. The map view shows theoretical airspace boundaries. Each segment represents a topic, with colour to show level: green for excellent; yellow for weak, and various intermediate stages (similar to OLMlets boxes and coloured nodes of Flexi-OLM). The detailed views are accessed from the simple ones, and include breakdowns of knowledge of topics and preparation time estimates until the trainee is likely to be ready for examination. Misconception statements can be accessed from all views (e.g. "the size of the radar beam grows proportionately with antenna size"). Flight Club2 was deployed for 4 weeks in a flight school. The 50 trainees studying for ground examinations were invited to volunteer, 43 of whom participated. An initial session was scheduled, and 28 users also logged on again at times of their choosing.

4. *OLMLA* (OLM for Language Awareness - row 4 of Fig. 1) has an intermediate level of complexity (between OLMlets/Flexi-OLM). It is designed for advanced language users such as non-native English speakers studying at English-speaking universities. Despite their advanced level, such students can still have problems which become particularly important in their academic writing. OLMLA is currently implemented for modal verbs. There are 4 OLM views: alphabetical index (verbs listed alphabetically with coloured nodes indicating skill level, and representations for any function for which a verb is used incorrectly); language function (verbs listed according to functions of use, also using coloured nodes to portray knowledge, and verbs used inaccurately); items showing knowledge or skill level (skill meters, including functions for which the verb is incorrectly used); example sentences which could be generated by the user according to their learner model (including more than one representation if a user is inconsistent in rule use). Expert equivalents are also available for direct comparison. OLMLA was evaluated in a lab setting with 15 engineering MSc student volunteers, who were non-native speakers of English. Interactions lasted about 40 minutes. Users were instructed to use the system as best suited them.

5. *Point of View* was designed for 10-11 year-olds learning science subjects (Earth, Sun, Moon; Health & Teeth; Food Chains & Life Cycles). Point of View has 9 topics in 3 areas and, as in the other OLMs, misconceptions are modelled (e.g. confusing predators and prey). Fig. 1 row 5 shows excerpts from the 4 model views: picture, ranked according to knowledge, text, hierarchy. Each view displays the 3 levels of

knowledge. In the text, this is indicated by 'high', 'medium', 'low'. In the ranked list, knowledge is shown by gold, silver and bronze, with subtopics in ranked position within the overall topic. The hierarchy also uses gold, silver and bronze to indicate knowledge, but integrated into a simple hierarchy. Here colours relate to each level (topic/subtopics) of the subjects modelled. The picture views relate to the topic being studied; e.g. in 'health and teeth', healthy teeth indicate stronger knowledge than the mouth with missing teeth. Text misconceptions descriptions are available in each view. Users were 12 primary school pupils. Evaluation took place in 2 20 minute sessions, separated by a week, so total interaction time for each child was 40 minutes.

6. *MusicaLM* aims to help learners of basic music theory formatively assess their understanding of intervals and basic chords. There are 4 topics (accidentals, basic intervals, rare intervals and basic triad chords), which together contain 18 concepts. The OLM presents examples of beliefs the learner may hold in 4 forms. As the model is built from the last 3 inferences for each concept, there may be up to 3 conflicting beliefs presented together in the learner model (most recent on the left). In the bottom row of Fig. 1, the first view is music notation: the notes give a musical example of the inferred belief. The second is the music notation’s complement in audio: the music (audio) view plays the music sequence to the learner, as if played on the piano. The third is the text view (e.g. a description of how the harmony is built, and the name of the inferred concept). The fourth view is spoken word: this is the aural complement to the text view (the information in the text view is spoken to the learner). Similar to some of the above OLMs, colour is used to identify how each belief compares to that which an expert would hold (expert beliefs can also be viewed, for comparison). MusicaLM was evaluated with 15 adult volunteers in 30 minute sessions.

3 Results and Discussion

Results. Table 1 shows number of model inspections in each system (combining totals for all views) to illustrate the scale of use, which can be compared to the number of users. It also gives percentagges of use of each view for each system, for comparison across systems. In the OLMs used alongside university courses there were many model accesses. In the lab studies, mean model viewings (after initial familiarisation) were lower. Lowest were viewings by Flight Club2 users. In OLMlets, most students used the skill meters, with accesses accounting for 80% of viewings. 10% used the graph (often in combination with skill meters), but there was little use of other views - though those who did use them, used them frequently. In Flexi-OLM preferences were more diverse. The lecture view (a tree structure) was the most commonly used, while the other tree (hierarchy) was used to a lesser extent (at a similar level to the text statements of knowledge). The map views (concept map and prerequisites) were used less, as was the alphabetical index, a list view. In contrast, the ranked list was used second most frequently. Viewings in OLMLA were evenly split, with each view attracting around 1/4 of accesses. Some users had a specific preference; others used more than one view. In Flight Club2, the more detailed model views are accessed through the simple ones. Therefore, the fact that the simple views were accessed more frequently, does not necessarily mean they were found more useful. The skill meters and runway are both forms of skill meter. The combined total simple viewings of skill meters and runway are 21%, with a combined total of 9% for the two detailed versions. For the simple views, this is similar to the map (19%) and radar (23%), suggesting different preferences amongst trainees, or trainees regularly using more than one simple view. However, the detailed map and radar views were used a little more frequently than the detailed skill meter/runway combined. Point of View accesses had a similar pattern to OLMLA, but only 3 of the 4 views sharing similar usage, and one accessed to a lesser extent. MusicaLM also revealed a range of preferences. Music notation (domain-specific) was consulted most frequently (50%), though music audio (the other domain-specific view) was consulted third most frequently (of 4).

Table 1. Number of users and inspections (total, mean) of the OLMs, and inspections of views

OLM	**OLMlets**	**Flexi-OLM**	**Flight C 2**	**OLMLA**	**Point of V**	**MusicaLM**
Users	810 (22 courses)	65	43	15	12	15
Total	59737	5163	439	266	265	380
Mean	74 (per model)	79	10	18	22	25
	80 sk m	12 hier	11 sk m-s	21 sk m	15 hier	50 notation
	10 graph	35 lecture	4 sk m-d	29 index	29 ranked	18 audio
	4 boxes	8 concept m	10 runway-s	25 func	27 text	26 text
	3 table-rank	5 prereq	5 runway-d	25 example	29 picture	6 spoken
	3 text	5 index	19 map-s			
		22 ranked	13 map-d			
		11 text	23 radar-s			
			14 radar-d			

Discussion. We here consider different methods of presenting the OLM to help users benefit from effects such as improved self-assessment skills [3], as they may pay attention to different information depending on whether the OLM is presented in a form they prefer [8]. Earlier work with Flexi-OLM and OLMlets suggested the utility of multiple OLM views in a university setting. We have here explored this further with fuller deployments of these OLMs, a deployment with trainee pilots, and lab-based studies with an additional 3 OLMs. The results show that across a variety of systems, although not always evenly divided, user preferences for model views differ. It is less important which views were preferred where the split was uneven, than the fact that there were a range of preferences that included the generally less commonly accessed views. This applies with both children and adults; with adults in independent learning and taught course contexts; with OLMs having different levels of complexity and methods of model externalisation; and OLMs in different subjects.

There was greater access to the OLMs deployed in courses. In both OLMlets and Flexi-OLM, there were stronger preferences for some of the views, and particularly for the OLMlets skill meters. However, users were also using the skill meters in combination with other views (especially graph); and some users used the skill meters rarely, having other preferences. The lecture hierarchy was used the most in Flexi-OLM, though the difference between choices was less strong than in OLMlets. The above suggests that, while some views may suit more students, they are not always the preferred method of accessing information and, indeed, even those who use the more popular views, do not necessarily use only those views.

When considering the lab-based studies of OLMLA and Point of View, the spread of use of views was more even – particularly with OLMLA. This may be because these were experimental scenarios, so users did not have the same motivation to use the OLMs for learning. Alternatively, the OLMLA views, although showing the same information, display it from slightly different perspectives. Consultation of a greater range of views might be considered more useful by learners. In Point of View, 3 of the 4 views were equally used, 27-29% of inspections, with the 4^{th} used for only 15% of inspections. The more complex hierarchy was less frequently used, suggesting that children found the simpler views easier. In MusicaLM the differences were larger, though still indicating variation in preferences - but a domain-dependent view (music notation) appeared particularly useful, being consulted for half the model inspections.

Flight Club2 had an initial scheduled session, and remained available for 4 weeks. 65% of trainees logged in at least one additional time. However, inspections of the model were lowest with Flight Club 2. This might be expected compared to OLMlets and Flexi-OLM, because these were deployed for longer. However, it is not clear why inspections were lower than in the lab-based studies. It may be because these were highly motivated users, learning entirely independently. Trainees were used to taking control of their learning, and were perhaps more proficient at self-assessment. Having viewed their model, they may not need to return to check their changing knowledge.

It would be interesting to consider whether greater access to a view is due to more users, or a view being more heavily used by a small group. However, as our specific concern is to support users with different preferences, the important point is that different views were accessed by learners. At this stage we recommend OLM designers consider multiple views, so learners may use the views that *they* find easier, and may use them in combination. We suggest this is particularly important in independent OLMs where externalisation of the model aims to prompt reflection and facilitate learner independence, but it may also be helpful in other integrated OLM contexts.

References

1. Bull, S., Kay, J.: Student Models that Invite the Learner. In: The SMILI Open Learner Modelling Framework. Int. J. Artificial Intelligence in Education, vol. 17(2), pp. 89–120 (2007)
2. Weber, G., Brusilovsky, P.: ELM-ART: An Adaptive Versatile System for Web-based Instruction. Int. J. Artificial Intelligence in Education 12, 351–384 (2001)
3. Mitrovic, A., Martin, B.: Evaluating the Effect of Open Student Models on Self-Assessment. Int. J. Artificial Intelligence in Education 17(2), 121–144 (2007)
4. Corbett, A.T., Anderson, J.: Knowledge Tracing: Modeling the Acquisition of Procedural Knowledge. User Modeling and User-Adapted Interaction 4, 253–278 (1995)
5. Dimitrova, V.: StyLE-OLM: Interactive Open Learner Modelling. Int. J. Artificial Intelligence in Education 13(1), 35–78 (2003)
6. Zapata-Rivera, J.-D., Greer, J.E.: Externalising Learner Modelling Representations. In: Workshop on External Representations, AIED 2001, San Antonio, Texas, pp. 71–76 (2001)
7. Kay, J.: Learner Know Thyself: Student Models to Give Learner Control and Responsibility. In: Int. Conference on Computers in Education, AACE, Charlottesville, pp. 17–24 (1997)
8. Bull, S., Cooke, N., Mabbott, A.: Visual Attention in Open Learner Model Presentations. In: Conati, C., McCoy, K., Paliouras, G. (eds.) UM 2007. LNCS (LNAI), vol. 4511, pp. 177–186. Springer, Heidelberg (2007)