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Comparing Student-Constructed Open Learner Model Presentations to the Domain

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Abstract. Increasingly, learning environments are opening the learner model to the user it represents. This paper describes a study in which students were able to create their own presentations of their learner model. We examine the nature of the learner model views created, and the degree of correspondence with the domain. Our results suggest learners have different preferences for the type of view they would like to create, and in many cases use informal or unstructured representational systems.

Introduction

Learner models have been externalised to the user using a variety of presentations (e.g. [1,2,3,4]), with one of the aims being to enhance reflection. Multiple representations have been argued to be effective in fostering deeper understanding of a task, as they can allow the use of complementary information processing methods and support individual differences [5]. While users of multiple-view open learner models have been found to have individual preferences for representation [6,7,8], the available views may not necessarily allow the learner to interact with the model in the most appropriate way *for them*, and a logical step may be to allow the learner to construct their own representation. Self-constructed representations potentially allow information to be usefully reorganised, aiding the monitoring of progress, highlighting problem areas, and facilitating self-explanations [9]. Some attempts have been made to allow the learner to influence the presentation of the learner model: STyLE-OLM [3] explicitly models understanding of conceptual relationships, with the task of constructing the model central to the interaction; in VisMod [4], the learner more simply selects the dimension (colour, size, length) for each of the model properties. This paper aims to investigate the type of representations learners construct in a more open scenario, and whether these representations are an accurate depiction of the domain. We present results from a study where students were able to create their own presentations of the learner model according to two styles of layout: tree and map.

1. The Flexi-OLM Open Learner Model

Flexi-OLM [7] is designed to prompt learners to reflect on their understanding of C Programming. Multiple-choice and short-answer responses contribute to a personal learner model, which can be viewed in seven different presentations, corresponding to four types of layout: tree (topic hierarchy and lecture outline); map (concept map and prerequisite layout); list (alphabetical index and list ranked according to knowledge); and textual. The views convey the same information – proficiency on individual topics – via a consistent colour scheme: well understood topics are coloured green and poorly understood topics white, with two intermediate levels indicated by shades of yellow. Red signifies potential misconceptions while grey denotes a lack of information (i.e. insufficient questions answered). Views differing in abstract structure may have similar relational structure, with the hierarchy and concept map based on conceptual relationships and the lectures and prerequisites views indicating sequences (see Figure 1). While all views contain the 43 learner model topics, some are augmented with meta-topics where knowledge is not modelled, but which allow the structure to make sense (e.g. 'operators', 'lecture 4' etc.). In the concept map, labelled arrows illustrate propositional relationships, while the prerequisites view uses unlabelled arrows and lines to model prerequisite and co-requisite relationships respectively.

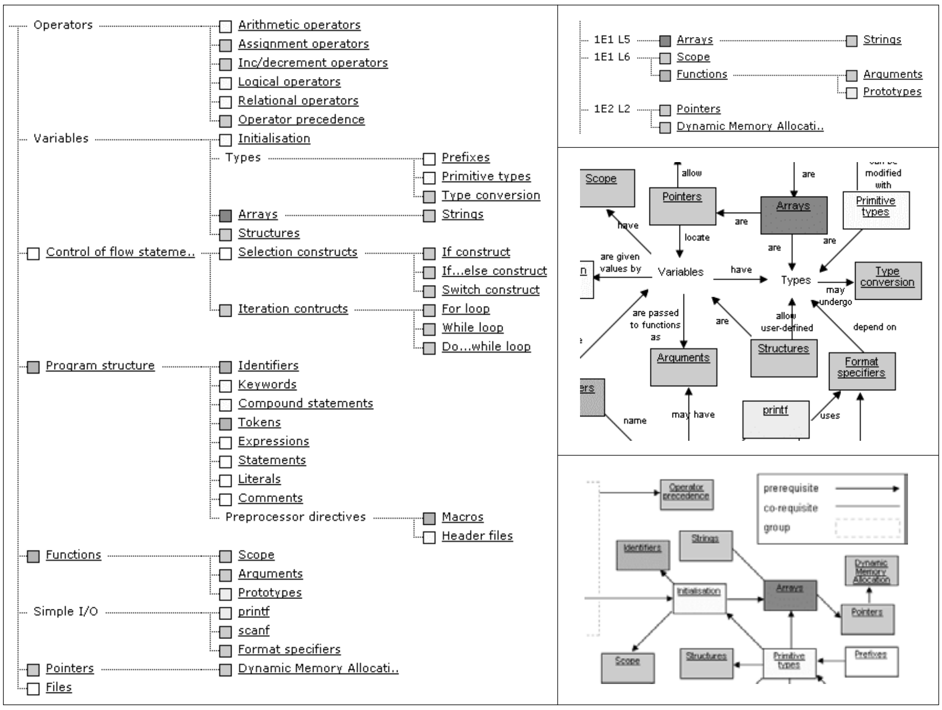

Figure 1: The hierarchy view plus excerpts of (top-bottom) the lectures, concept map and prerequisites views

For the study, 'tree' and 'map' views were added, in which users could create their own layout. (Since the list view is constrained to a simple sequencing of topics, allowing less potential for creative layout, we focus on use of the tree and map views.) The views contain a list of all topics in the learner model and a blank area onto which the topics may be dragged and arranged (see Figure 2). 'Custom' topics may be added, although knowledge level is not represented for these. In the tree view, any topic dragged onto another becomes a child of that topic, while topics may be positioned anywhere in the map view and linked with labelled arrows if necessary.

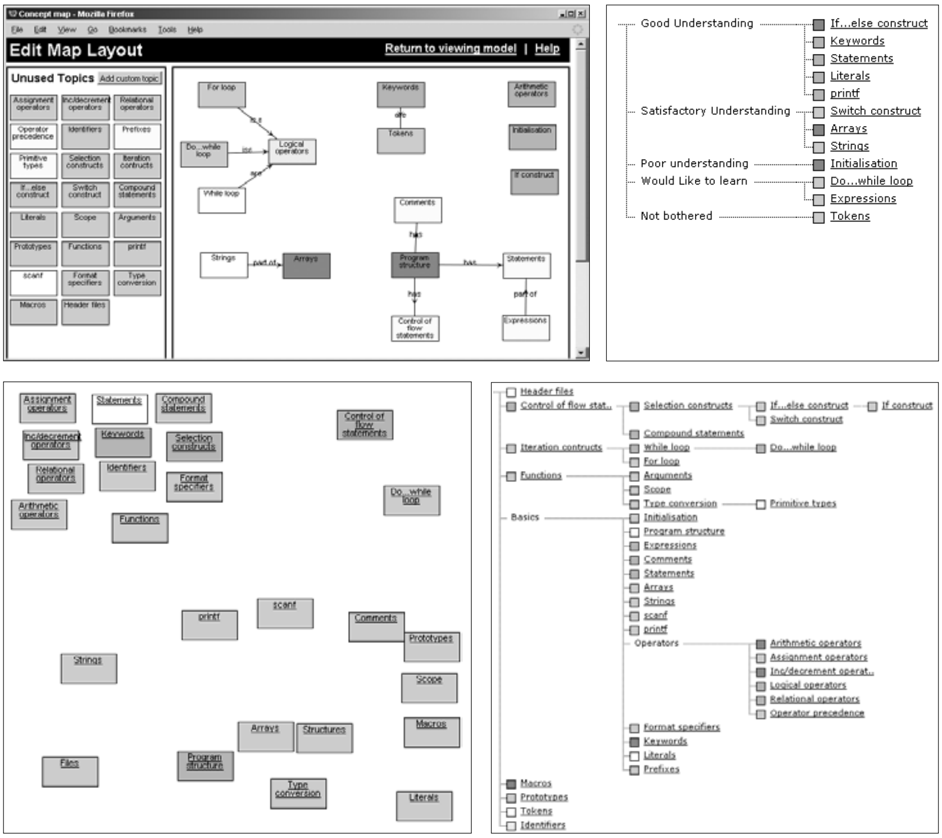

Figure 2: Representation construction interface with examples of learner-constructed views

2. What Kind of Learner Model Presentations do Users Create?

A study was carried out into the types of presentations users create when given the opportunity to construct their own views of the learner model. We investigate two issues: the kind of information learners are trying to convey, and whether the views created are accurate according to the domain.

2.1. Participants, Materials and Method

36 third-year undergraduate students participated in the study as part of a course on interactive learning environments, while a further 6 (3 MSc, 3 PhD) also volunteered, making a total of 42. The students had prior experience of a simple open learner model system [6]. After dividing into two groups, participants began by answering questions to allow Flexi-OLM to build a learner model. Group A were then invited to create views of their learner model data using the two templates (tree, and map), while

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Group B used the predefined views. Later, each group switched to the opposite set of views. Students were not instructed on the type of views to create, but instead asked to arrange each of the self-constructed layouts in the way that suits them best.

To facilitate an analysis of the meaningfulness of user-created views, all 903 possible pairings of the 43 domain topics were analysed by a C Programming expert and classed as either strongly related, weakly related or unrelated. The exact nature of the relationship was not specified as this may be somewhat subjective.

2.2. Results

Figure 2 shows examples of the learner-constructed learner model views.

2.2.1. The Map View

Several students made little or no use of the map view, while the majority did not use the facility to link topics with labelled arrows, and only seven employed more than two such links in their layout (See Table 1). Students using the predefined views first (Group B) appear to create slightly more detailed maps than those beginning with the self-constructed views (Group A). Only four students used custom topics in their map.

Table 1: Number of participants vs. number of topics and links used in map view

	Number of topics			**Number of links**		
	Group A	**Group B**	**Total**	**Group A**	**Group B**	**Total**
None	3	3	6	14	9	23
1-2	3	0	3	5	7	12
3-5	7	7	14	2	2	4
6-10	3	4	7	0	2	2
More than 10	5	7	12	0	1	1

Table 2 examines the nature of the links created, with each column representing an individual user, and rows corresponding to categories of link. Conceptual relationships were classed as propositional (e.g. 'logical operators - *are* - operators'), non-propositional (e.g. 'if-else construct - *constructs* - if construct'), or incorrect (e.g. 'for loop - *is a* - logical operator'). Relationships classed as non-conceptual related to planning (e.g. '*spend more time*'), level of difficulty (e.g. '*easy*'), or understanding (e.g. '*learnt*'), while the remainder expressed no apparent relationship.

Table 2: Nature and quantity of links in map view

Link Type	**Group A**							**Group B**											
Non-conceptual relationship		2									1						1		39
Propositional conceptual relationship																		6	
Non-propositional conceptual relationship						3						1		2	2		6		
Incorrect conceptual relationship															1			3	
No relationship	1		2	2	2	1	4	1	1	1			2			4	1		
Total links	**1**	**2**	**2**	**2**	**2**	**4**	**4**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**3**	**4**	**8**	**9**	**39**

Only one student created a map using propositional conceptual relationships, while two others used mainly correct non-propositional relationships, and three used exclusively planning/knowledge related links. Around half made only links which indicated no relationship. More students from Group B created meaningful links.

Some students appear to have clustered together related topics without linking them. For each topic in a user's layout, the closest topic was determined, with preference given to those connected with an explicit link. The strength of the connection between each of these pairs of topics was recorded. Figure 3 indicates the number of students having a particular percentage of adjacent topics which are related, while Figure 4 considers only strongly related topics. The nine students using fewer than three topics were excluded from this analysis (at least three topics are required to indicate clustering since two topics would be adjacent by default; three allowed inclusion of students who were concentrating on a small area of their model).

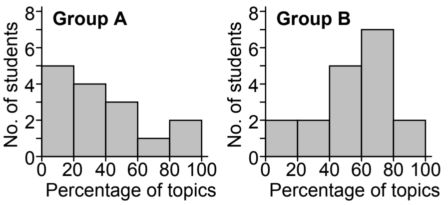

Figure 3: Topics related to nearest topic

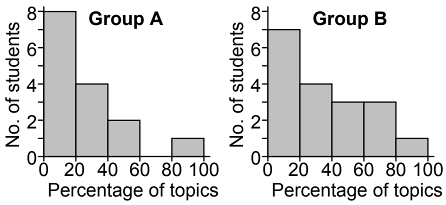

Figure 4: Topics strongly related to nearest topic

A large number of students created maps where the majority of adjacent topics were conceptually unrelated and few constructed layouts with a strong conceptual relationship between a majority of topics. Students using the predefined views before creating their own appear more likely to group conceptually related topics.

Figure 5 illustrates the percentage of related adjacent topics for stronger ability students (those above the median according to the learner model) compared to weaker ability students. Level of understanding of the domain does not appear to have had an impact on whether students positioned related topics adjacent to each other.

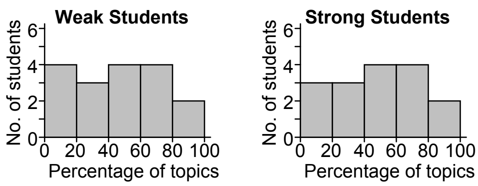

Figure 5: Topics related to nearest topic for strong and weak students (Group A and B combined)

2.2.2. The Tree View

Table 3 shows the number of topics used in the tree view. As with the map view, several students made no use of the tree view or added only one or two topics to it. While fewer students in Group B used the tree view, there were also more students who created trees using a larger number of topics. Seven students created custom topics, with the most created being five. Table 4 shows the number of levels used in the hierarchies created by students. A number of students created linear structures either with all topics at the root level, or with each topic having only one child. The highest number of levels was 5 (the predefined hierarchy and lectures views have 3 and 4 levels respectively).

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Table 3: Number of topics in tree layout

No. of Topics	Group A	Group B	Total
None	2	5	7
1-2	3	2	5
3-5	8	3	11
6-10	4	8	12
More than 10	4	3	7

Table 4: Tree depth

Depth	Group A	Group B	Total
0	2	5	7
1	7	3	10
2	6	7	13
3	3	3	6
4	1	2	3
5	2	1	3

An analysis of the relationship between child and parent topics was carried out on the 25 layouts with more than one level. Custom parent topics were classified as either conceptual (e.g. ‘operators’) or related to planning or knowledge (e.g. ‘to learn’, ‘don’t understand’). Model topics were classed as strongly related, weakly related, or unrelated, according to the previous definitions. Table 5 indicates the categories accounting for the majority of the topics in each user’s tree layout.

Table 5: Most common relationship to parent topic in tree layout

Majority category		Group A	Group B	Total
Custom (Planning / knowledge)		1	2	3
Custom (Conceptual)		0	2	2
Related	Mostly strongly	3	4	7
	Mostly weakly	0	2	2
Unrelated		8	3	11

Three users constructed layouts based on level of understanding or learning sequence while two used custom topics to create a conceptual hierarchy. Of the remainder, there were 9 cases where the majority of topics were conceptually related to the parent and 11 where the majority were unrelated. Students constructing their own views before using the predefined views were more likely to associate a topic with a conceptually unrelated parent. Since simply associating related topics does not guarantee that the relationship is hierarchical, each link was analysed and classed as either hierarchical or non-hierarchical. Figure 6 shows the proportion of topics having a hierarchical relationship to the parent, for each user in Group A compared to Group B, and Figure 7 presents a similar comparison between the strong and weak students. Around a third of the students constructed layouts where almost all of the relationships were hierarchical, while the remainder constructed maps where few were. This did not appear to be affected by whether students began with the self-constructed or predefined views, or by level of understanding according to their learner model.

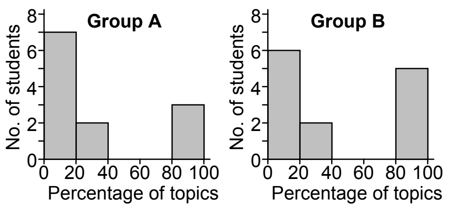

Figure 6: Percentage of topics with hierarchical relationship to parent (Group A / B)

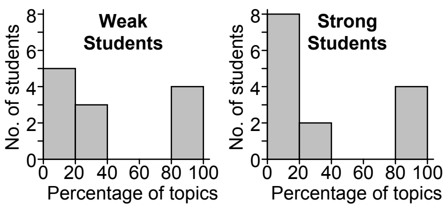

Figure 7: Percentage of topics with hierarchical relationship to parent (strong/weak students)

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2.3. Discussion

An interesting variety of user-created layouts was observed, suggesting differences in the types of learner model view students would like to use. This may reflect preferences for representational system, or may be dictated in part by the task an individual is working on. For example, recognising problem areas may be easier with a particular kind of layout than assessing understanding on a particular part of the course, deciding what to learn next, or identifying inaccuracies in the system's model.

In contrast to the detailed conceptual and sequential structures of the predefined views, user-constructed representations were generally more informal and much less detailed, with few students creating their own labels (custom topics), and a minority using links. This is not surprising since the students received no training in techniques such as concept mapping, and Cox [9] notes that representations created for private use tend to be "less fully labelled, sparser, and [sometimes] only partially externalised". Perhaps more surprising is the fact that so few students created hierarchies which were in fact hierarchical, as they may be more familiar with this type of structure due to its everyday use (in file managers etc.). A possible explanation could be that some students are using the self-constructed views as a means of focusing on a portion of the model by including only a small number of topics at a time. With significance attached to presence rather than position of a topic, a seemingly disorganised map or un-nested tree may still be useful. Provision of more generic layout elements (lines, boxes etc.) may enhance support for informal representations.

In some cases students appeared to group topics that did not share any conceptual relationship. It is possible that these layouts would have improved as understanding increased, although results did not indicate a link between ability and correspondence of representation and domain. Nevertheless, layouts which appear meaningless to an observer may still convey meaning to the individual concerned, and constructing an incorrect layout may raise awareness of areas of poor understanding in a way not possible with the predefined views.

Students beginning with the predefined views tended to include more topics in the map (with a larger number of meaningful links) and appeared more likely to use hierarchical relationships in the tree. One explanation could be that users who began with self-constructed views were not aware of how to use links and custom topics, whereas those starting with the predefined views had seen examples. The predefined views may also have improved conceptual understanding, as students using these first were more likely to group conceptually related topics together in their own views. However, students who used the self-constructed views first and made an attempt to organise the topics conceptually but did so erroneously may learn more than students using the predefined views first who simply repeated correct conceptual relationships they observed there.

A longer term evaluation could indicate whether the ability to create accurate conceptual layouts improves as domain knowledge increases, or whether maintaining an accurate layout is not considered important. Involving learners in the analysis phase may provide insight into their intentions when working with the self-constructed views. It would also be useful to evaluate the educational impact of individual views, in order to determine if the inherent representational guidance offered by each can be exploited as a means of focussing attention on particular aspects of understanding (in line with similar work in the area of collaborative discourse [10]). If this is the case, it may be worth providing training for those students having difficulty using the representations, or including a facility for verifying relationships. There are also possibilities for using learners' self-constructed views to inform the learner model content itself, although if students find ‘inaccurate’ structures helpful as open learner models, a system would need to distinguish whether the learner's created structure actually reflects their understanding. Alternatively, it may be possible to provide the beneficial features of the self-constructed views within the original views. For example, allowing students to hide topics may allow them to focus on a section of the model without needing to create their own view.

3. Summary

Students were given the opportunity to create their own views of an open learner model, and were found to create informal representations lacking in detail, labelling, and in some cases accuracy. There are indications that creating learner model presentations from scratch may pose difficulties for some students, since those using predefined views first used some representational features more fully and often created conceptually more accurate layouts. However, informal representations may still be useful, and the diversity of views created may suggest that learners benefit from the flexibility of creating their own layouts. Further work is needed to assess the effect on learning, and to study how an individual’s representations might change over time.

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