Exploring the Effects of Open Social Student Model Beyond Social Comparison

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Abstract. In our journey exploring the effects of Open Student Model (OSM) on students working with programming problems and examples, we have incorporated the idea of social visualizations to extend OSM to Open Social Student Modeling (OSSM). Although comparison features in OSSM, where a student can compare herself to the group or individual peers, have shown to increase students' work, we now shift our attention to other effects. The goal is to explore the OSSM effects beyond comparison, particularly metacognitive support, and we propose a representation of the OSSM towards these lines.

Keywords: Open Student Model, Open Social Student Model, Metacognition, Self-Regulated Learning, Group-Awareness

1 Introduction

Open Student Model (OSM, also called Open Learner Model or OLM) consists of a set of features, usually visual and sometimes interactive, that shows data of progress, mastery of knowledge, or other statistics of the activity of the student to herself [3]. This data comes from the internal user model that the computer-based educational system maintains to bring in adaptive and tutoring functionalities [2]. By showing the user model to the learner, OSM fosters metacognitive processes like self-awareness [4] and can be further used as a navigational tool. In the past we have explored different forms of guidance based on OSM. KnowledgeZoom (KZ) [1] implements a fine-grained student model based on concepts hierarchically organize in an Ontology of Java programming. KZ presents the student model using treemap that shows different levels of details as the student "enters" each of the concepts. This approach allows the student to have an overall view and a detailed view of her progress and knowledge gaps just few clicks away. We have also incorporated the idea of social visualizations and extended the OSM to an Open Social Student Modeling (OSSM) [8, 10]. OSSM seeks for sharing aggregated or individual OSM among the students allowing social comparison and social guidance dynamics. Figure 1 shows a screenshot of the MasteryGrids system, our current OSSM implementation. The first 3 rows represent the progress of the current student, the comparison between the student and the group, and the progress of the rest of the class, respectively. Cells represent topics, ordered as they are covered in the course. Darker colors mean higher progress in the content. The student progress is colored in shades of green, and the group (the average of the class) is represented with a blue color palette. The middle row shows a differential color that turns green when the student is more advanced than the group and blue otherwise. By clicking in a cell, the student has the access to educational material included in the selected topic (in the figure, the cell corresponding to the topic *Loops While* has been clicked.) The second group of cells shows the progress of all individual students in the class, anonymized, ranked by the amount of progress (advanced students at the top) using shades of blue.

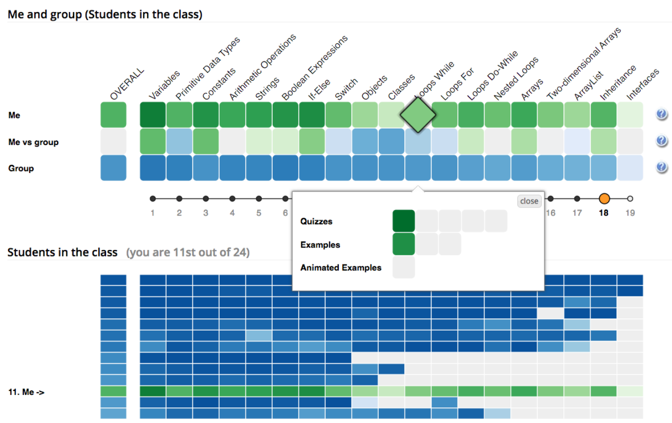

Fig. 1. MasteryGrids OSSM interface.

Overall, our efforts to implement OSSM have been focused on exploiting comparison effects and we have observed in classroom studies that this kind of features make students work more and follow others [8, 10]. Also, the sort of guidance produced by advanced students over non-advanced students is quite conservative, and we further proposed a guidance approach incorporating OSSM and adaptive navigation features (work presented as a poster in AIED 2015 [1]). We now shift our attention to explore the OSSM effects beyond comparison, particularly how OSSM can be applied to support metacognitive processes involved in self-regulated learning activities. The motivation for our vision comes from two areas. On the one hand, the strong ideas behind OSM are related to metacognitive support: OSM increases self-awareness and self-control of the learning process [4]. We believe that the metacognitive support of OSM reaches another level in OSSM. For example, OSSM can give students a sense of common difficulties helping them to make better self-judgments when facing failure. On the other hand, although our approach to OSSM does not incorporate direct interaction and collaborative tools, there is a sort of "indirect interaction" or "soft

[1] Poster title: *Off the Beaten Path: The Impact of Adaptive Content Sequencing on Student Navigation in an Open Social Student Modeling Interface*

collaboration" happening mediated by the cognitive aspects of the group information displayed. This social dimension can be used to enrich OSM features, for example, to guide students using the traces of others. In the next sections we explore related work about open student model, metacognition in self-regulated learning, the measures of metacognitive processes in computer-based learning environments, and social awareness in computer-based collaborative environments, and from these ideas we propose a representation of OSSM.

2 Open Student Model and Metacognition

Open Student Model (or Open Learner Model) discloses the user model that the system maintains to the learner. As a result, OSM is a tool for self-awareness and learning monitoring. In the review of OSM work, Bull and Kay [4] described different systems incorporating OSM features or indicators supporting metacognition, including high level indicators of performance, OSM negotiation features (the learner can negotiate her user model with the system), and fine-grained indicators at finer levels of knowledge components (for example, concepts). Fine-grained conceptual representations of OSM, where the student can discover gaps in her knowledge that are hidden in high level indicators, have been attempted in a number of works [11, 13]. A common approach to fine-grained models involves a detailed domain model that can be represented as a concept-map or concept tree where nodes are concepts in the domain linked by the ontological or semantic relations among them. The learner model is an *overlaid* status of the learner in each of the concepts and it is represented by using, for example, colors [3]. A common problem of fine-grained models is that they can become very complex and hard to understand by the student. Visual techniques has been proposed to deal with this issue, for example, our system KnowledgeZoom uses semantic-zooming [1]. Open Student Model is also acknowledged to be of benefit when shared. For example, the instructor can perform a detailed monitoring of the learners, the learner can find collaborators by inspecting other models, compare with suitable ones, or improve group awareness through open group model [3]. Our vision of OSM incorporates the idea of sharing the OSM (we call it Open Social Student Model) and a fine-grained model that serves the student to make a more precise judgement of her own learning process.

3 Self-Regulated Learning and Metacognition

The research in Self-Regulated Learning (SRL) puts importance to feedback mechanisms in the development of cognitive and metacognitive processes. Feedback is not only related to the learner seeing summaries of her activity traces or providing information to others or the educational system, but also the internal feedback processes the learner develops while reflecting on the activities, for example the update of beliefs about herself and beliefs about the content of study [5]. Moreover, Butler and Winne [5] noted the heterogeneous and adaptive nature of self-regulation (here *adaptive* refers to the behavior of the learner that adapts during the learning experience) and they stressed the need of study it in a finer grain, i.e. continuously, while the learning activity is being performed. They proposed a broader view of self-regulated learning and feedback by describing four stages or elements: knowledge and beliefs, selection of goals, tactics and strategies, and monitoring. We take on this view and see ideas that can be applied in OSSM in each of these 4 stages. For example, for knowledge and beliefs, OSSM might project conflicting information to learner's self-efficacy beliefs (as the learner can compare her performance against others), and this discrepancy could be set to improve self-beliefs when possible. About goals, feedback can help the learner to set her goals and to make a good decision while navigating the content. Establishing a proper strategy to accomplish a goal might be difficult when the task is unfamiliar to the student, and here OSSM can use traces of other students to implement navigational guidance. Monitoring processes need to be supported by feedback information regarding both the current goal and about the progress on the learning activities.

Greene and Azevedo [7] saw the opportunity that Computer-Based Learning Environments (CBLEs) introduce for observing and measuring the learning process in detail, and reported a number of works using different forms of metacognitive measures and interventions in CBLEs. According to them, there are three types of techniques for measuring metacognition: 1) by self-reported instruments usually applied before or/and after the learning activity, 2) by using activity logged by the system or collected by sensors, and 3) inferred from explicit feedback given by the learner as the result of interacting with the system. They emphasized the idea that fine-grained metacognitive measure allows different levels of analyses, including semantic and statistical analyses of the activity, and analysis of sequences of actions in the time, which is in line with what Butler and Winne [5] recognized as necessary to study metacognition: continuous and on-line measurements. From the summary of Greene and Azevedo [7], we consider three broad ideas to incorporate in OSSM. First, it is important that the OSSM system collects all possible information while the learner performs the learning activities. Second, richer analyses and guidance can be achieved by incorporating some sort of dialogue or active interaction in the system that can be used to capture self-reported metacognitive state in real-time (for example asking the student what was the most difficult exercise, or asking the student to verify her model and write down her corrections). Third, the representation of the user model evolution over time (for example the progress in the last week), along with representation of the sequences of actions of the student and of the group or peers, can contribute to a better monitoring and planning tasks.

4 Social Awareness Tools

Janssen and Bodemer [9] summarized ideas of cognitive group awareness and social group awareness in collaborative activities supported by computer. Awareness, a process of inherent metacognitive character, can be of the type *Cognitive Group Awareness*, mainly about the knowledge and expertise of others (content space), or of the type *Social Group Awareness*, mostly about the levels of participation or engagement of peers and the quality of the interaction (relational space). Both broad types of group awareness are not exclusive of each of the spaces. For example, Cognitive Group Awareness also interacts with the relational space. Following this framework, we situate our idea of OSSM as a Cognitive Group Awareness (OSSM shows the knowledge/progress model of peers and the group), and we see the value of incorporating a dimension of Social Group Awareness, for example, by showing indicators of visits, attempts, and other current activity made by peers. Also, as Janssen and Bodemer suggested [9], using Cognitive Group Awareness features will also produce an impact in the relational space and we should not ignore it. For example Glahn, Sprecht and Koper [6] observed that even though a group awareness indicator (showing average of the group performance) produces the longest and strongly positive effect in the amount and the quality of work, it also produces frustration in non-contributing users and in some cases, the belief of vicious competitive behaviors of others. Moreover, the question is how to grasp the benefits of the group awareness features in OSSM on both content and relational spaces. Different group-awareness tools are implemented by Papanikolaou [12] in the system INSPIREus, including indicators of effort, progress, working style, personalization features, and social construction of knowledge (summarizing the type of discussions in forums). Students reported that the indicators allowed them to better understand their weaknesses and helped them to better plan their activities. We take on these ideas to incorporate different types of indicators for reflection, self-monitoring and comparison, specially, by combining indicators of activity with pedagogical information that sets the context of the desired metacognitive processes. Similar to INSPIREus, we maintain a domain model consisting of concepts mapped to the content material and activities, and structured using different semantic relationships, which can be used to provide indicators at different levels, for example high level indicators summarizing a topic.

5 A Concept-Map OSSM

We propose to complement our current OSSM MasteryGrids with a network representation of the concepts as the student progress in the learning activities. Activities are mapped to a set of finer grained concepts and these concepts get connected as the student practices activities containing pairs of concepts. Thus, the network representation or concept map, gets more connected as the student practices the concepts with different other concepts. We recognize that in many domains *mastery* is reached as the student is able to connect different concepts. We hypothesize that this concept map will allow students to have a finer and detailed view of their models, thus engage them in deeper metacognitive processes. On the other hand, the representation grows naturally as the student *connects* concepts, thus giving an idea of the dynamic progress or advance in pursuing learning goals. We plan to incorporate features supporting other metacognitive processes of goal setting and learning strategy. The learner should be able to choose concepts she wants to target, and the OSSM incorporates an indicator of the overall progress of the goal set. Recommendation and navigational clues are giving to signal concepts that should be targeted first and which activities to do to progress on those concepts. Collaborative filtering techniques can be used to grasp the *wisdom of the crowd* in order to power such recommendation mechanisms. For example, once a goal is set, the system can find the traces of other students that set similar goals in the past and use this information to recommend which activities to do. Each concept in the map can show information of the overall activity of the group related to the concept, for example to give an average of the progress on the concept. One important aspect on OSM is letting the learner correct or negotiate the model. Our implementation should allow students to change their knowledge levels through selected assessment items.

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