Towards providing notifications to enhance teacher's awareness in the classroom

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Abstract. Students often need prompt feedback to make the best from the learning activities. Within classrooms, being aware of students' achievements and weaknesses can help teachers decide how to time feedback. However, they usually cannot easily assess student's progress. We present an approach to generate automated notifications that can enhance teacher's awareness *in runtime*. This paper formulates the theoretical framing and describes the technological infrastructure of a system that can help teachers orchestrate learning activities and monitor small groups in a multi-tabletop classroom. We define the design guidelines underpinning our system, which include: i) generating notifications from teacher-designed or AI-based sources; ii) enhancing teacher's awareness in the orchestration loop; iii) presenting both positive and negative notifications; iv) allowing teachers to tune the system; and v) providing a private teacher's user interface. Our approach aims to guide research on ways to generate notifications that can help teachers drive their attention and provide relevant feedback for small group learning activities in the classroom.

Keywords: Orchestration, Notifications, F2F Collaboration, Classroom, CSCL

1 Introduction

Teachers have a crucial role as managers of the different elements of the learning environment [3]. They are responsible for conducting the class design, ensuring productive use of time, resources, learning technologies and providing attention to each student. Students often need scaffolding and prompt feedback on performance to make the best from the learning activities designed by the teacher [14]. Thus, besides *orchestrating* the multiple activities that occur in different dimensions within the classroom, teachers also should provide feedback to the students. The provision of feedback is an essential part of effective learning achievement [14, 15]. Being aware of students' progress, achievements and weaknesses can help teachers enhance the provision of timely and effective feedback [13]. In the classroom, this support should ideally be provided while the learning activity is still underway, so necessary adjustments can be made. However, even though providing timely feedback is very important, teachers can easily become absorbed with their multiple *orchestration* responsibilities, making it difficult for them to attend to the students who need it most.

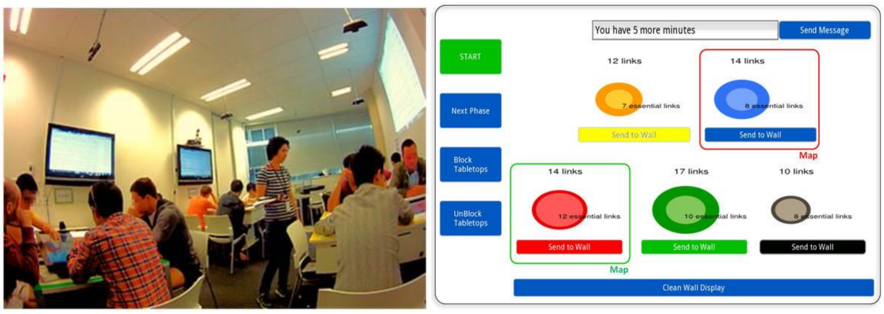

Fig. 1. Left: Multi-tabletop pervasive classroom for small group collaboration. Right: Notifications in the teacher's dashboard.

A wide range of learning technologies have been used over the past years to improve instruction and learning in the classroom [11]. However, the development of tools to effectively support teacher's awareness and help them provide enhanced feedback to students has been relatively neglected [2, 8]. Research suggests that some sort of integrated assessment is needed in order to give effective feedback [1]. Unfortunately, teachers often cannot assess the quality of students' artefacts, partial outcomes, student's performance or their collaborative interactions *on-the-fly*. This opens up an opportunity to exploit the use of emerging technology that can unobtrusively capture aspects of students' activity and then automatically alert teachers about events that are hard to assess within the time constraints of a class.

We propose an approach to automatically generate notifications for teachers in a timely manner during a class. Our system is implemented in a classroom enhanced with pervasive technologies: the MTClassroom [8]. This learning environment is ideal to plan and orchestrate small group activities by exploiting the affordances of five horizontal and three vertical shared devices (Figure 1, left). In our setting, the notifications can be generated by assessing, in real-time, qualitative aspects of the knowledge artefacts being built by the students (in the form of concept maps) and comparing them with a model of expert knowledge and a set of misconceptions defined by the teacher. Alternatively, notifications can be generated based on quantitative aspects of student's collaboration that may be associated with undesired patterns of interaction, such as social loafing [10] or strategies of low achieving groups [9].

2 Related Work

Previous research has delivered tools that enhance teacher's awareness and reflection through different dashboards or visualisations. Verbert et al. [16] observed that these kinds of tools have been deployed in three learning contexts: online learning settings, face-to-face lectures and face-to-face small group work within classrooms. Teacher's awareness tools and the automated generation of notifications have only been explored in online learning settings [16]. For the very different case of face-to-face work in classrooms, an important example tool is the Tinker Board [3], that shows information on a large display to support reflection on a small-group activity. Similarly, the Tinker Lamp [3] is a widget that students can use to indicate to the teacher which stage of the activity they are up to. Martinez-Maldonado et al. [8] explore the impact of showing visualisations of student's data to help teachers decide where to place her attention. Other studies have agreed that this type of information can be useful for teachers using both private or public displays [4] and can be integrated with different devices like tablets [5], smart-boards [3] and tabletops [8]. Our approach is the first effort we are aware of that describes guidelines to build a system that provides teachers with automatic notifications in the classroom.

3 Context of the Learning Environment

As a foundation to define our approach, we first introduce the context of the learning environment. Then we describe an example authentic scenario. We built our system targeting university level learning activities for tutorial classes that can be held in the MTClassroom [8]. This is the first classroom with multiple interactive tabletops that can (i) unobtrusively capture data about each learner's activity, linking it to the learner's identity; and (ii) provide orchestration tools and real-time student's data analysis. It is composed of 5 interconnected multi-touch tabletops, each well suited for face-to-face work in groups of up to 5 students and enhanced with the CollAid [7] sensing system. Each tabletop records the activity of students within each group to a central repository that can be accessed by other services in real-time. One of these services generates visual indicators to enhance teacher's awareness and shows them in the MTDashboard. The MTDashboard is displayed on a handheld device that allows teachers to orchestrate the MTClassroom (Figure 1, right). One of the applications that can be used in this learning environment is CMate [7]. This is a concept mapping tool that records activity logs, traces of the task progress and information about student's maps. A concept map is a directed graph in which nodes represent the main *concepts* of the subject matter and the edges are labelled with a linking word to form meaningful statements called *propositions* [12]. More information about the environment can be found in the technical papers of CMate [7] and MTClassroom [8].

An example study where our approach can be applied was conducted during an undergraduate course on *Human-Computer Interaction* (HCI). A total of 95 students were enrolled in this subject. Students were divided at the beginning of the semester into 6 tutorial classes, with around 15 students each. Each tutorial was facilitated by a class teacher. In the example course, the students were organised into 24 groups of 3, 4 or 5, who worked together during the tutorial sessions. The same 1-hour weekly tutorial ran in each tutorial, with three different class teachers (the main teacher had one class and the other 2 class teachers had 2 and 3 classes). The learning goals for students using CMate commonly consist of collaborating with their group to create a concept map that answers a *focus* question. In this way, the teacher needs to monitor up to five small groups building five different concept maps in parallel. It is not easy for the teacher orchestrating the class while, at the same time, assessing each concept map to know if students are building a high quality map or have misconceptions.

4 Approach and Design Guidelines

Figure 2 illustrates the context where our approach is deployed and the process that the teacher can follow to design, enact and diagnose the classroom activity. We describe this process in terms of the design guidelines underpinning our system.

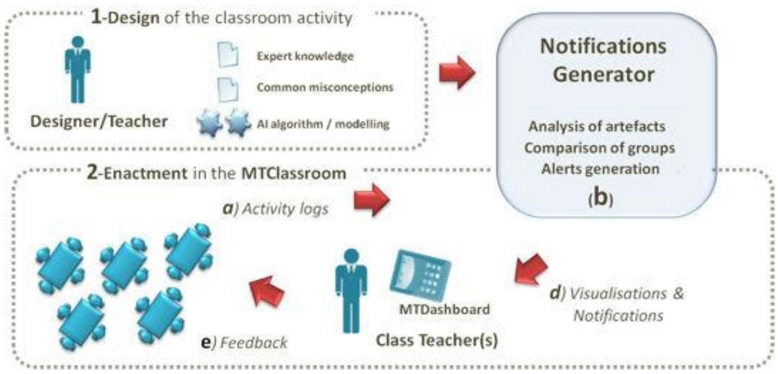

Fig. 2**.** MTFeedback context: conceptual diagram of the approach.

i) Generating notifications from on teacher-designed or AI-based sources. This process starts with the teacher designing the learning activity before the classroom sessions (1). In this stage, the main teacher designs a macro-script for the sessions. The teacher can define a source of expert knowledge and common misconceptions that can be used to match student's artefacts automatically. In our study, these can be defined by the teacher using CMapTools, a third-party widely used concept map editor [12]. The expert knowledge is represented as a concept map that contains the propositions that the teacher considers the students should have in their maps. Common misconceptions that the teacher wants to track are defined separately, as a set of propositions. The teacher can also select AI-based sources to generate notifications that may consist of matching students' activity logs with patterns of interaction associated with either high or low collaboration groups [9]. For example, our previous work, using sequence mining on tabletop touch data, found that it is possible to identify high collaborative groups which often work in parallel, interacting with other students' objects and focus on the crucial elements of the problem to solve [9].

ii) *Enhancing teacher's awareness in the orchestration loop*. The designed activity is then enacted in the classroom (2). In the classroom, teachers commonly follow an orchestration loop [3] where small group activities can be described as follows: the teacher monitors the groups, assesses their performance to decide which group(s) may need support, attends to the chosen group and starts the cycle again. Our approach aims to support the teacher's decision making about which groups most need their immediate attention by enhancing their awareness of each group's progress in this orchestration loop. We describe this as the following process: a) The pervasive interactive tabletops capture, synchronise and gather activity logs of each group in a central repository; b) our system compares each group's logged activity against the expert knowledge and the list of misconceptions; c) notifications may be generated accordingly and sent to the MTDashboard; d) the MTDashboard interface shows visualisations and notifications to the teacher; and e) the teacher looks at the dashboard and decides whether a certain group(s) needs feedback or not.

iii) Presenting both positive and negative notifications. It has been found that receiving too many notifications can produce a negative effect on users, as it makes it hard to readily determine what has changed over time [6]. To avoid this, we give two types of negative notifications and one positive notification; the choice of these was defined by the main teacher's pedagogical requirements. First, a *Misconception Notification* (MN) is triggered for the group that has the most misconceptions in the classroom. Our system assesses groups every half a minute, deciding which group, if any, needs a new notification generated. This way, the teacher can eventually determine whether all groups have recurrent misconceptions or if the whole class needs a clarification of the activity. Similarly, the system may provide alerts when patterns of either high or low collaboration are detected for certain groups.

iv) Allowing teachers to tune the system. It is important to allow the teacher to tune or configure the rules used to generate notifications as well as the timing or pace in which they are displayed on the teacher's dashboard. For example, a second negative notification is the *Slow-Group Notification* (SN). For this, our system compares the progress of all the groups in the classroom and flags a group as being left behind if it has less than half of the propositions created by the top achieving group. This rule was tested on a dataset collected in sessions run in previous semesters [8] but it can be tuned by the teacher. By contrast, a *Positive Notification* (PN) can be generated when a group had at least P% of their propositions matching the expert knowledge (the parameter P was tuned by the teacher to be 50% in our study).

v) Providing a private teacher's user interface. Figure 1 (right) shows the teacher's dashboard as displayed on a handheld tablet. The interface has a set of buttons for the teacher to control the classroom technology. It also features up to five visualisations, each associated with an active tabletop. Inspired by [8], we used visualisations that indicate the size of each group's solution and the proportion that matches the expert knowledge (a figure with an outer and an inner circle respectively). The notifications appear as a square (red for negative or green for positive) around the group information. For example, Figure 1 (right) shows two notifications: a negative notification for the group with the most misconceptions (red square around the *blue table*), and a positive one for a group that included half of the expert knowledge and had no misconceptions (green square around the *red table*). Teachers can be instructed to get a message on the screen with more information about the notification by tapping inside of the coloured square.

5 Conclusions

Providing teachers access to automatically captured data can enhance their awareness [4], however, effective ways to show this information in the classroom are still needed. This paper describes the theoretical and technological framing, and the design guidelines, of a system that can provide teachers with notifications of small group work in runtime. We aim to exploit student's data captured at a multi-tabletop classroom to alert the teacher about aspects of student's collaboration, and their solutions, that cannot be easily analysed by the teacher on-the-fly. This can help teachers provide immediate or delayed feedback. Even though our approach can be generalised to other kinds of small group learning activities, this paper presented a learning context in terms of a collaborative concept mapping activity as an instance of the application of our approach. The sources to generate notifications can be simple (expert knowledge and misconceptions defined by the teacher). Our future work will investigate the impact of using our system with real teachers and students, in-the-wild. Future work should also consider the use of machine learning techniques that can detect potential problems in groups to alert teachers proactively.

References

1. Brown, S. Assessment for learning. Learning and Teaching in Higher Education 1(1): pp. 81-89 (2004)
2. Bull, S., Wasson, B., Johnson, M. D., Petters, D., Hansen, C. Helping Teachers Effectively Support Group Learning. In: Intelligent Support for Learning in Groups - (ITS'12). (2012)
3. Dillenbourg, P., Zufferey, G., Alavi, H., Jermann, P., Do-Lenh, S., Bonnard, Q. Classroom orchestration: The third circle of usability, in Proc. CSCL 2011. pp. 510-517 (2011)
4. Kharrufa, A., Martinez-Maldonado, R., Kay, J., Olivier, P. Extending tabletop application design to the classroom, in Interactive Tabletops and Surfaces 2013. pp. 115-124 (2013)
5. Kreitmayer, S., Rogers, Y., Laney, R., Peake, S. UniPad: orchestrating collaborative activities through shared tablets and an integrated wall display, in Proc. Ubicomp 2013. pp. 801-810 (2013)
6. Lurie, N. H., Swaminathan, J. M. Is timely information always better? The effect of feedback frequency on decision making. Organizational Behavior and Human Decision Processes 108(2): pp. 315-329 (2009)
7. Martinez-Maldonado, R., Collins, A., Kay, J., Yacef, K. Who did what? who said that? Collaid: an environment for capturing traces of collaborative learning at the tabletop, in Interactive Tabletops and Surfaces. pp. 172-181 (2011)
8. Martinez-Maldonado, R., Dimitriadis, Y., Kay, J., Yacef, K., Edbauer, M.-T. MTClassroom and MTDashboard: supporting analysis of teacher attention in an orchestrated multi-tabletop classroom, in Proc. CSCL2013. pp. 119-128 (2013)
9. Martinez-Maldonado, R., Yacef, K., Kay, J. Data Mining in the Classroom: Discovering Groups' Strategies at a Multi-tabletop Environment, in Proc. EDM2013. pp. 121-128 (2013)
10. Martinez-Maldonado, R., Yacef, K., Kay, J., Schwendimann, B. Unpacking traces of collaboration from multimodal data of collaborative concept mapping at a tabletop, in Proc. ICLS 2012. pp. 241-245 (2012)
11. Muir-Herzig, R. G. Technology and its impact in the classroom. Computers & Education 42(2): pp. 111-131 (2004)
12. Novak, J., Cañas, A. The Theory Underlying Concept Maps and How to Construct and Use Them In:Florida Institute for Human and Machine Cognition(2008)
13. Race, P. Using feedback to help students learn. HEA, York: pp. (2001)
14. Shute, V. J. Focus on formative feedback. Review of Educational Research 78(1): pp. 153-189 (2008)
15. Stronge, J. H. Qualities of effective teachers. Association for Supervision and Curriculum Development, Alexandria , VA (2007)
16. Verbert, K., Govaerts, S., Duval, E., Santos, J., Assche, F., Parra, G., Klerkx, J. Learning dashboards: an overview and future research opportunities. PUC: pp. 1-16 (2013)