Real-Time Visualization of Student Activities to Support Classroom Orchestration

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Abstract: Data logged within technology-based learning environments have the potential to support instructors' orchestration of learner activities. Whereas many learning environments now feature student and teacher dashboards, which promote reflection on activities after the fact, the affordances of displaying these data in real time is only beginning to be explored. To be useful, however, these data must be made accessible and actionable. This interactive demonstration will showcase designs for technologies that visualize student activities in real-time during technology-enhanced activities, with the aim of supporting instructors' orchestration. Together, they projects from various contexts with similar goals, it highlights common challenges, issues, and strategies with regard to the design and implementation of these tools.

Keywords: classroom orchestration, design, information visualization, real-time data, teachers, technology

Introduction

The trend toward technology-enhanced, open-ended inquiry-based curricula (Scardamalia & Bereiter, 2006; Engle & Conant, 2002; Slotta & Linn, 2009) is placing a higher orchestrational load on teachers (Dillenbourg 2012; Tissenbaum & Slotta, 2015a). As students engage in more self-paced, choice-driven, and collaborative learning environments, the task of guiding student progress grows more complex. While telemetry data—that is, measurements captured and displayed for the purposes of monitoring—are proving advantageous for research into student learning (Baker & Siemens, 2014), solutions for harnessing this data as a tool for teachers have only begun to be explored. In spaces where learners' knowledge evolves at different paces and across multiple trajectories, teachers are faced with such decisions as when, who, and how to help (Tissenbaum & Slotta, 2015b); how to pace whole class and individual progress (Nussbaum, Alvarez, McFarlane et al., 2009; Roschelle, Rafanan, Estrella et al., 2010); how to distribute materials (Simon et al., 2004); and how to organize and manage the social structures among students across online and face-to-face settings (Dimitriadis, 2012). This *orchestration* of classroom activities (Dillenbourg, Jarvella, Fischer, 2009) has been highlighted as a major research design challenge within the learning sciences community (STELLAR, 2011).

In response, there has been increased interest in the affordances of technology-enhanced environments to support learning activities in real-time through automated scoring and guidance, real-time mining of telemetry data, and adaptive feedback (VanLehn, 2011; Berland, Davis & Smith, 2015; Leacock & Chodorow, 2003). While these technological solutions can reduce teachers' orchestrational load, it is important to ensure that teachers continue to have active roles as conductors of classroom activities rather than as "guides-by-the-side" (Koller et al, 2011; Roschelle & Pea, 2002). To this end, we investigate technologies that can provide teachers with more control over class progression and actionable real-time insight into the state of knowledge at the individual, group, and whole class levels. Generally termed orchestrable or orchestable technologies (Tchounikine, 2013), these tools provide teachers with specific insight into the state of the class and provide and an added layer of flexibility in how classroom activities unfold. An important feature of such technologies is that they do not require the teacher to take action, nor does the system itself take action, rather they give the teacher better information to help him or her make decisions (Tissenbaum, 2014). These technologies take on many forms, including tablet-based dashboards, ambient displays, and other similar aggregated visualizations.

While these technologies are growing in popularity, the various ways they have been implemented and a thoughtful comparison of their relative successes (and where they have fallen short) has not been presented in a unified way. To address this need within the learning sciences community, this symposium brings together five projects that are investigating the role that orchestrational technologies can play in giving real-time classroom support. During the symposium, participants will discuss the curricular context in which it is situated, the orchestrational needs they aimed to address, and the successes *and shortcomings* of their implementation.

Objectives

Together, these contributions aim to start conversations about issues involved in designing and implementing these systems: What data should be captured, and who should make this decision (Matuk, Cocco & Linn; Tissenbaum, Berland & Lyons)? What activities should these data support (Schwendimann; Tissenbaum & Slotta)? How should these technologies be integrated into teachers' practices (Matuk, Cocco & Linn; Vitale, Gerard & Linn)? How should these data be visualized (all)? These works also investigate affordances of technology and information visualization for supporting sociality, collaboration, decision-making, and inference. This symposium will create opportunities to examine commonalities and divergences in strategies, theoretical frameworks, and pedagogical goals of efforts to harness data in support of in-the-moment teaching. It will fuel discussions among the Learning Sciences community of concrete solutions to the problem and advantage of data in education.

Contexts, settings, and foci

The contributions represent different pedagogical contexts, including game-based learning (Plass), workplace training (Schwendimann & Boroujeni), and science inquiry (Matuk, Cocco & Linn; Tissenbaum & Slotta; Vitale, Linn & Gerard). They also cross physical settings, from formal (e.g., K-12 classrooms) to informal spaces (e.g., workplaces and museums). The foci of contributions range from understanding how such tools can support the seamless transition of learners' activities between learning settings; to justifying design decisions and exploring associated student learning gains; to investigating how technology can alert teachers and/or mentors of critical moments for intervention. All contributions place an emphasis on teacher-centered design, valuing teachers' existing practices, and investigating ways technology can enhance those practices.

Session format

To promote active and productive discussion, the format of this symposium will be an interactive demonstration. Following brief teaser presentations on each project, the audience will be invited to explore stations at which presenters will have set up demonstrations of their technologies. They will have a chance to explore and critique these designs in terms of their value for orchestrating learning activities. During the final portion of the session, we will return to a whole group format. Our discussant will offer insights, and the audience will be invited to ask questions, and to contribute reflections on their own and the presenters' work.

Designing a real-time intelligent support for museum interpreters

Mike Tissenbaum, Matthew Berland, and Leilah Lyons

With the increasing inclusion of technology rich interactive and immersive exhibits in museums there is a growing challenge to supporting docents in knowing when participants are struggling at an exhibit and if they are close to "giving up." This is especially true in exhibits where multiple participants can engage at the same time and can enter or exit the exhibit within the flow of activities (rather than a simulation or activity having clear start and end points).

In response to the challenge of supporting museum docents within open-ended museum exhibits, we have developed a tablet application for an interactive tabletop exhibit (called *Oztoc*) at the New York Hall of Science (Lyons et al., 2015). The tablet application (Figure 1) collects the real-time logs of participants' actions, and based on their emergent patterns, alerts the docent when a participant is engaged in "unproductive perseverance" (continuing to repeat the same pattern over and over) or is close to a "frustration point" (i.e., about to give up). In order to recognize which patterns were most indicative of participants engaging in either condition, we used a combination of grounded theory stemming from video observations of participants engaged around the table and sequential data mining (an educational data mining technique that highlights underlying patterns in complex data sets).

As part of this symposium, we will show how patterns for intervention are identified and selected, museums docents' feedback on the use of the tablet, and an analysis of data from a live museum context. We will also make the tablet application and source available for those interested.

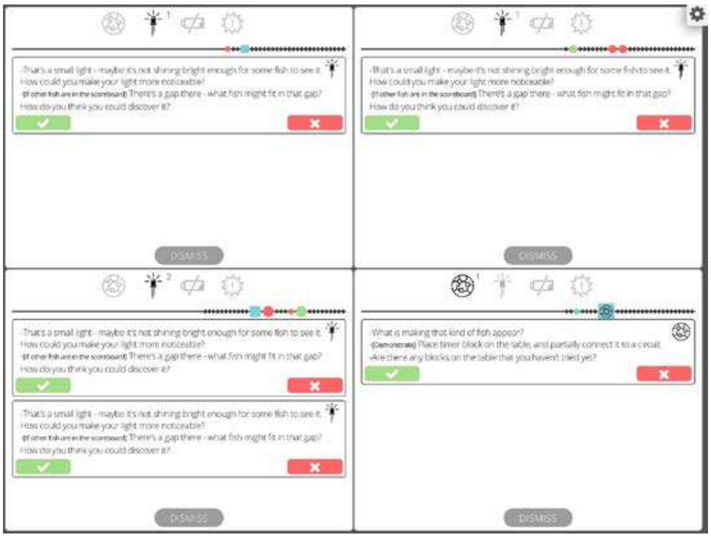

Figure 1. Oztoc real-time docent tablet application screen.

A teacher-centered approach to designing a real-time display of classroom activity

Camillia Matuk, Felipe Cocco, and Marcia Linn

Online learning platforms, such as the Web-based Inquiry Science Environment (WISE, wise.berkeley.edu), are evolving to capture nuanced pictures of the processes, in addition to the outcomes, of student learning. As such, they make it possible for teachers to quickly ascertain patterns in students' thinking, and to devise more timely and targeted guidance. However, many questions remain about how to best make this information accessible and useful to teachers, as well as about how to integrate the resulting tool into teachers' existing practices.

We describe the design of a real-time summary report that displays students' progress based on data logged by WISE (Figure 2). Information boxes display averages of such information as the time spent on a step in a unit, the number of visits to each step, and the number of revisions per step. These boxes include a snapshot of ranked data (e.g., a list of the top three steps on which the most time was spent), which on clicking, lead to explorable visualizations of whole class data. With this information, teachers can streamline instruction, promote student reflection and motivation, identify students in need of help, identify areas in the unit for improvement, and manage students' progress (Matuk et al., 2016).

Audience members will be invited to explore a live summary report and associated data displays. We will discuss how, through classroom observations, teacher interviews, and participatory design workshops, we come to determine and refine visualizations appropriate for their anticipated functions. Building on prior work, which reveals which logged data teachers prioritize for which decisions (Matuk et al., 2015, 2016), we discuss our explorations into the display of new information, with the aim of supporting evidence-based instruction ranging from planning logistics (e.g., how to pace progress given the steps students may have skipped); to selecting guidance strategies (e.g., what feedback is most effective based on students' improvement through revision); allowing teachers to draw on archived data from their own and others' past curriculum implementations to inform current implementations; and making correlations among available data to answer their own questions about student learning.

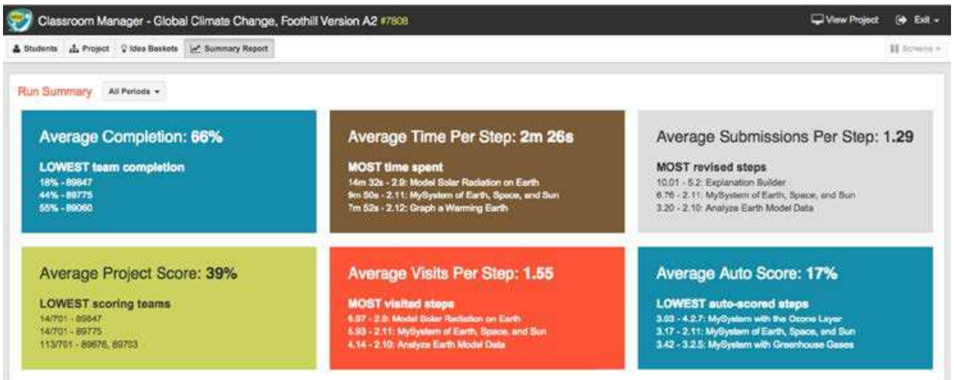

Figure 2. WISE's classroom summary report.

Real-time visualization of student activities during learning with simulations and games in the Digital Reference, Experiment, and Assessment Manager (DREAM)

Jan L. Plass, Nik Hajny, and Al Olsen

This demonstration will show how we present real-time information of student activities during learning with simulations and games to instructors. In order for real-time information to be useful for classroom orchestration, it needs to be current yet not updated too frequently; aggregated enough to be easily comprehended, yet detailed enough to be informative; and actionable without being too prescriptive.

Based on our previous work investigating how teachers use games as tools for formative assessment in the classroom (Fishman, Snider, Riconscente, Tsai, & Plass, 2015), we are designing a visual dashboard for simulations and games in our Digital Reference, Experiment, and Assessment Manager (DREAM) platform that makes key information available to instructors in ways that meet the above requirements. Based on this research, this dashboard (1) links the game's incentive structure (points, scores, stars) to learning outcomes, (2) provides learning progress for either individual students or groups of students, (3) incorporates outcomes from other, related activities students performed concurrently or in the past, and (4) allows teacher to configure the display of the information to meet their needs (Figure 3). In particular, teachers are able to switch among views with different levels of granularities of the data. This could be as coarse as visualizations of the overall progress of the class on specific learning objectives or standards, or more detailed showing class progress on specific sub-standards. Other visualizations show the overall class progress on performing a specific task or activity, progress of an individual on performing this activity and their comparison to the class average, or specific information of individual in-game events and student responses. Figure 3 shows the top level page from which this information will be accessible.

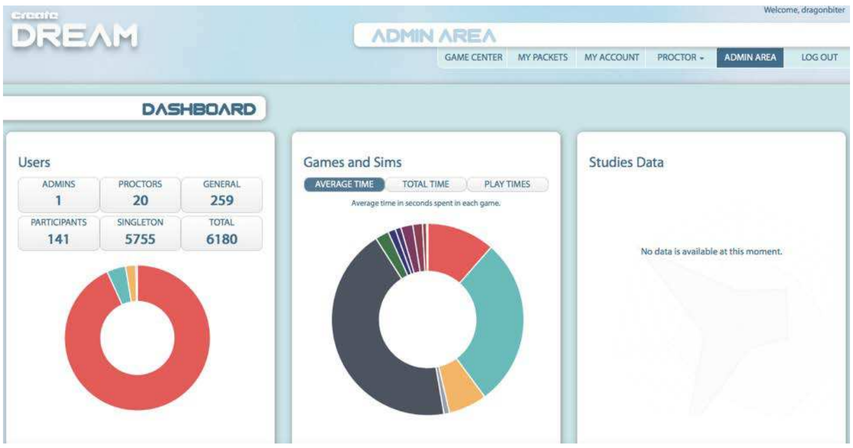

Figure 3. The DREAM dashboard.

At the symposium we will discuss how our research with teachers using games for formative assessment informed our design of the DREAM dashboard and will show how instructors can use the different views to inform their decision-making in class.

REALTO teacher dashboard to support the integration of school and workplace experiences

Beat Schwendimann and Mina Shirvani Boroujeni

Learners moving between different contexts, such as school and workplace, often struggle to integrate different learning experiences. As a result of the separation of different learning contexts, knowledge is often situated in one of these contexts and does not get used in others. The multi-context approach often leads to disconnected, inert, and fragmented knowledge that cannot be applied to solve problems. Our pedagogical model (Schwendimann et al., 2015) builds on the idea of capturing learning experiences to make them available for orchestrated reflection activities at a later time. The REALTO platform is being developed to support learners to capture, annotate, and share their rich experiences through different media (text, audio, photos, and videos) through mobile and desktop devices. REALTO aims to be a social learning space for sharing experiences across various learning spaces by connecting learners and teachers. Teachers can build on these captured experiences to integrate knowledge across context contexts by orchestrating different classroom activities. Two different elements of REALTO support teachers' classroom orchestration. First, interactive learning analytics dashboards allow teachers to monitor students' activities and identify patterns (Figure 4). Teachers can distinguish different engagement levels by tracking posts, comments, tags, and annotations. These indicators allow tracking student activities inside and outside of the classroom in real-time. Second, the REALTO notification system informs teachers (and learners) of new submissions, late submissions, and recent social annotations. Teachers can set up and track activities with deadlines. Research and development of REALTO aims to provide teachers with tools to orchestrate blended activities that support the integration of learning experiences from different contexts. REALTO is currently being used in several schools in a co-design process involving teachers, learners, and researchers.

As part of this symposium we will present audience members with samples of data captured within the REALTO platform to show how REALTO: 1) uses learning analytics to generate interactive visualizations that support teachers to monitor the class; and 2) can help teachers identify student engagement patterns in real-time.

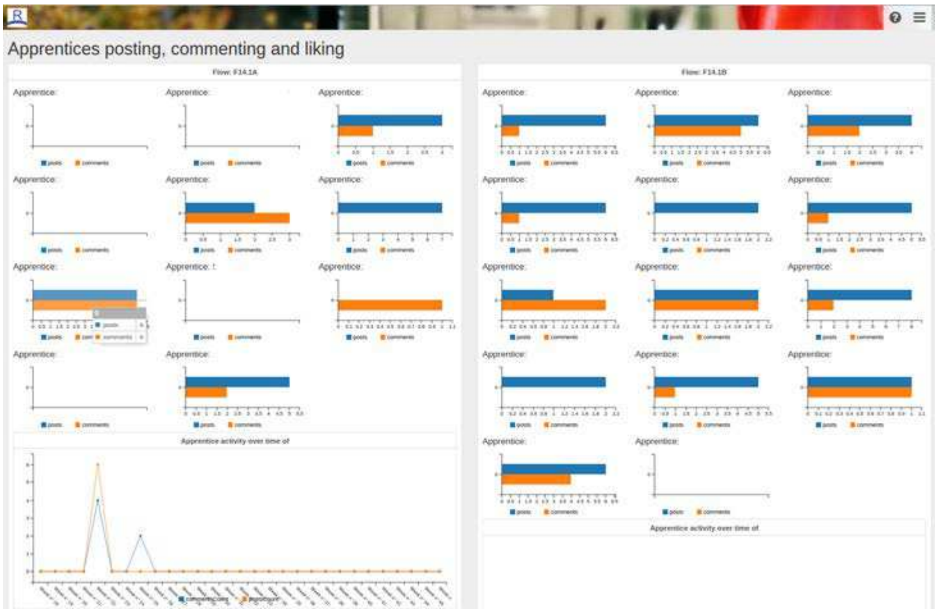

Figure 4. Real-time teacher dashboard showing learner's activities in an online environment (REALTO).

Supporting real-time teacher orchestration in a smart classroom setting

Mike Tissenbaum and James D. Slotta

There is growing interest in the learning sciences community in “smart classrooms” - technology mediated spaces in which the physical space itself becomes a mediator of student learning. In smart classrooms students are not simply browsing information passively, but are also creating, attaching, connecting, and taking data with them from one location to another, and from one group to the next. However, these immersive and interactive environments are likely to be more complex and dynamic than previous generations of computer supported learning environments (Slotta, 2010), placing additional load on teachers to track the milieu of actions taking place, the growth of students knowledge, and where and when they are most needed, most of which would be invisible or excessively time consuming for teachers to compile themselves (Tissenbaum & Slotta, 2013).

In order to understand the role orchestrational supports could play in such a curriculum, using the SAIL Smart Space (S3) architecture, we developed a specialized tablet application (Figure 5) that provided a teacher with control over the flow of activities and a real-time alert when he was needed. In order to provide the teacher with critical prompts and information, a central part of the development of this tablet was the development of intelligent software agents that could track the “state of the class” and respond to emergent patterns. In order to evaluate the effectiveness of the tablet application, we engaged four sections of high school physics students in a real-time smart classroom activity. When students reached a critical moment at the activity (as set by the teacher during co-design), an S3 agent sent a message to the teacher on his tablet to inform him he needed to review the group’s work. He could then either approve the work and let them progress to the next step, or ask them to further refine their ideas and resubmit them. Across all four sections, the teacher approved the work of all 16 groups (four in each section), but asked six (38%) to resubmit their work for approval (with one group being asked to re-submit twice. To assess the effect of the teacher’s reviewing and approving of groups’ work on their final completeness score (a rubric co-develop with the teacher) we went back and rescored the work of all the groups the teacher asked to resubmit (i.e., before their edits). In total, the groups re-submitted seven times, resulting in an average change of .67 in their assessed score - indicating that alerting the teacher when and where to best intervene had a meaningful effect on groups’ knowledge construction. As part of the symposium, this paper will discuss the design-based iterations that led to the teacher tablet application used in this scenario (including previous designs that were less effective for real-time interventions) and show video of the tablet being used by the teacher during the live smart classroom activity.

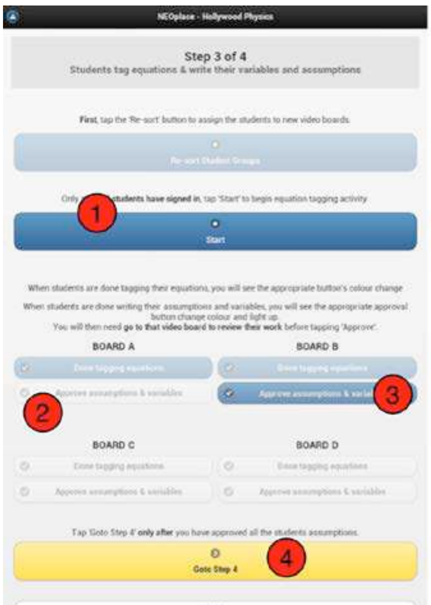

Figure 5. The Teacher Orchestration Tablet. The tablet (1) Enabled the teacher to start an activity; (2) Showed each group’s progression through the activity; (3) Alerted the teacher when a group reached a point for intervention (pre-defined by the teacher); and (4) Let the teacher advance the class to the next step.

Visualizing data from automated scores to help teachers guide inquiry with scientific visualizations in diverse classes

Jonathan Vitale, Marcia Linn, and Libby Gerard

Inquiry-based science instruction promotes meaningful, self-directed student interaction with content. Teacher guidance helps students to make meaning from these interactions. Guiding struggling students who are working asynchronously can be a challenge for teachers. To help teachers determine which students would most benefit from their guidance, we have developed and tested a series of indicator tools within the Web-based Inquiry Science Environment (WISE). We use automated scoring for essays and concept maps to analyze student thinking and provide relevant visualizations to teachers to facilitate instruction. We have explored a series of visualizations of this data for teachers, including a progress monitor, student response viewer, and real-time alerts. In this demonstration, we detail the development and use of the real-time alerts (Figure 6) in diverse classrooms, drawing on data from classroom observations, teacher and student interviews, student science learning outcomes, and design iterations. We studied 6 teachers who used the real-time alerts in 3 schools with over 700 students. We compared different automated indicators of student progress to inform the alert system, including the time students spent on given activities, and the artifacts they generated. Additionally we compared teacher alerts to automated, text-based guidance. Results indicate that the teacher score-based alerts can be more effective than automated guidance, but require active teacher participation and high familiarity with student ideas. In interviews the teachers praised the teacher alerts and also indicated a desire for professional development to help them anticipate student difficulties and to plan guidance that facilitates inquiry. As part of this symposium, visitors will be invited to try the real-time alert system from both the students' and teachers' perspectives.

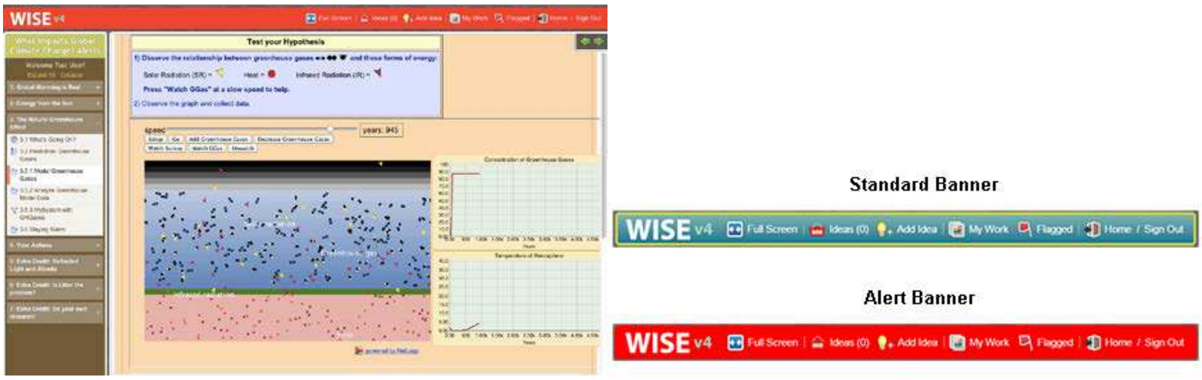

Figure 6. Left: The alert banner within the WISE environment. Right: The standard (top) and alert (bottom) banners.

Conclusions and implications of the symposium

This symposium comes at an important point in the learning sciences. Increasingly, learning interventions are infused with technology and bring with them new kinds of information that instructors need to keep track of and respond to in real-time. Despite this shift, there have been few frank discussions about what actually works and how instructors actually use the tools provided to them. This symposium brings together a set of projects that sit at the forefront of this research by examining the role that orchestrational technologies can play in highlighting patterns in student work, alerting instructors at critical moments in live activities, tracking student progress across formal and informal activities, and developing complex visualizations of student engagement and learning in real time. Through these examples, this symposium aims to advance the discourse and understanding of such supports and to provide a clear set of exemplar cases to support members of the broader learning sciences community in advancing their own designs.

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