Orchestrating Collaborative Science Curriculum across Formal and Informal Contexts

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Abstract: This demonstration presents an evolving body of work around the development of a new open source framework for smart classrooms – known as Sail Smart Space (S3) – that supports research of complex pedagogical configurations, emphasizing student collaborations, emergent knowledge repositories, and real-time semantic analysis of student data. The project involves the development of Physics curriculum in two diverse classroom settings: a first year college Physics course and a grade 12 advanced placement physics class. This session will acquaint attendees with the iterations and refinement involved in bringing such a curriculum into a classroom, and the unique opportunities such environments afford researchers and teachers. The presentation will provide a brief history of the project to its present state both technically and pedagogically; followed up by a hands-on demonstration of the current iteration; and closes with a series of videos and discussions about our vision of the future of the S3.

Introduction

The purpose of this demonstration is to present an evolving body of work around the development of a new open source framework for smart classrooms – known as Sail Smart Space (S3) – that supports research of complex pedagogical configurations, emphasizing student collaborations, emergent knowledge repositories, and real-time semantic analysis of student data. The current project involves two research teams working at the University of Toronto and Dawson College in Montreal in the development of Physics curriculum for enactment in two diverse classroom settings: a first year college Physics course and a grade 12 advanced placement physics class. The goal of this session is to acquaint attendees with the successive iterations and refinement involved in bring such a curriculum into a classroom, and the unique opportunities such environments afford researchers and teachers in the orchestration of collaborative activities for students. The presentation will begin with a brief history of the successive implementations of the project to its present state both technically and pedagogically; this will be followed up by a hands-on demonstration of the current iteration with attendees; and will close with a series of videos and discussions about our vision of the future of the S3 platform and a question and discussion session with the audience.

Theoretical Background for Project

Developing Environments for 21st Century Learning

The everyday lives of children are increasingly being shaped and mediated by technology; and yet, the schools tasked with educating these children have been largely untouched by the evolving digital landscape (Buckingham, 2007; Tyack and Cuban, 1999; diSessa, 2000). A recent report on cyberlearning (NSF, 2008) concluded that a lack of deliberate efforts to coordinate technology into science and math curriculum could seriously hinder students, in terms of their success in related careers, and more generally in becoming productive members in a modern technological society.

Creating an environment where the production, assessment, and aggregation of content results from the contributions of all members of the community rather than from a single authoritative source, mirrors the types of interactions with technology that students are often faced with outside of the classroom (e.g. Flickr, YouTube, Facebook). Implementing such a "socially oriented" model of classroom instruction (Ullrich et al., 2008) can enable students to take more active roles in the classroom environment and to become creative producers of their own curriculum content (Buckingham 2007; Ito et al., 2009). Introducing digital media into the learning environment can free students from traditional "canned lab" approaches, and embed problem-solving activities in more deeply collaborative curriculum (Slotta & Linn, 2009; Soloway et. al, 1999). Complicating the successful integration of these kinds of technologies into classroom curriculum is that most educators are not sufficiently familiar with new pedagogical models of technology-enhanced learning (Ertmer, 1999; Slotta and Linn, 2009). Additionally, those developing technology environments for learning often do not have the pedagogical understanding to develop effective applications for their products (i.e., the use of "smartboards" and clickers, which are typically left to the teachers to determine how best to use them). This issue can be particularly problematic if not properly implemented due to the significant costs in both resources and class time in introducing these kinds of environments into a classroom setting.

In response to this challenge a central goal of this research has been to bridge the gap between technology and pedagogy, working closely with teachers, in the development of learning spaces that harness technology to provide powerful new opportunities for students and teachers alike.

Scripting Learning across Contexts

Developing curriculum in a technology enhanced learning environment can allow for the real-time tracking of the products of student interaction across a variety of contexts (formal/informal environments) and configurations (individual/small group/whole class interactions), giving teachers and researchers new opportunities to design the ways in which students interact with the curriculum. The intentional orchestration of the nature and timing of activities, as well as the particular roles that each student plays within the larger curriculum is often compared to that of a theatrical script (O'Donnell & Dansereau, 1992). To be effective, the design of these scripts must take into account the unique contexts in which each of these activities takes place. Individual actions – such as asking a question, answering a question, and the evaluation of answers – may all take place at different times and locations, effecting how students understand and process an activity (Lemke, 2000). Careful scripting of a curriculum can help insure that the natural granularity of the individual tasks matches the granularity that is most beneficial to student learning (Dillenbourg & Jerman, 2007). Scripting can also build time and opportunities for reflection (O'Donnell & Dansereau, 1992) which not only help students build their own personally relevant understandings from their educational experiences (Bransford et al., 1999; Krajcik et al., 2008; Linn and Eylon, 2006), but can also provide rich data for teachers to gain insight into students' understandings of the curriculum. Access to student ideas during instruction can allow teachers to adjust their instruction "on the fly" to more effectively aid students in overcoming misconceptions or developing deeper understandings of the curriculum under investigation (Dillenbourg & Jerman, 2007).

Description of the Learning Environment and Project Iterations

Developing a Technology Rich Learning Environment

New forms of knowledge media and data repositories offer a wealth of opportunity for researchers and curriculum designers who can take advantage of the varying contexts (i.e., within the classroom, at home, or in field activities) and devices (e.g., laptops, smartphones, interactive tabletops, and large format displays). This new functionality allows for exciting new kinds of instruction where students collaborate across contexts, dynamically generate knowledge, build on peers' ideas, and investigate questions as a knowledge community.

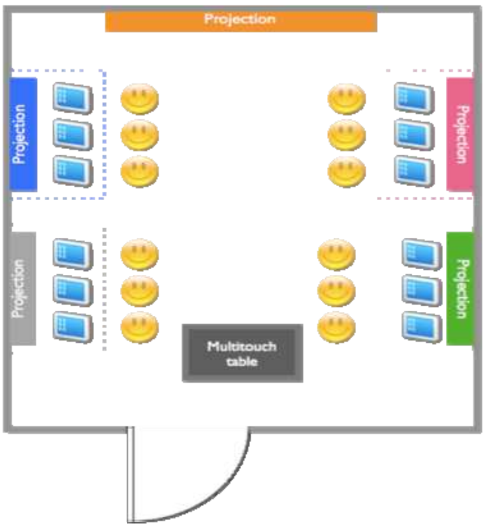

Figure 1. S3 Smart Classroom Setup.

This research recognizes the potential of technology enhanced learning environments to enable such pedagogical models. To this end, we have advance the notion of a "smart classroom," which employs a wide range of technologies for investigating a full spectrum of collaborative inquiry and knowledge construction activities. The work centers around the development of a powerful, flexible open source platform called SAIL Smart Space (S3), which in turn builds on the rich framework of SAIL (Scalable Architecture for Interactive Learning – Slotta & Aleahmad, 2009). S3 specifies a framework in which devices and displays are configured, building on a set of core underlying technologies: (1) a portal for student registration and software application management; (2) an intelligent agent framework for data mining and tracking of student interactions in real time; (3) a central database that houses the designed curriculums and the products of student interactions; and (4) a visualization layer that controls how materials are presented to students on various devices and displays (Slotta, 2010). The current S3 smart classroom implementation involves four large projected displays in each corner of a classroom, a fifth, larger, multi-touch display on the

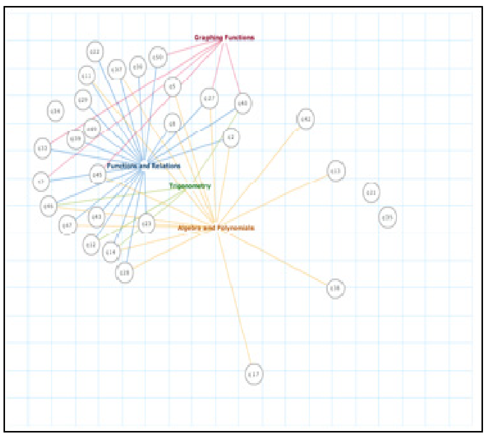

Figure 2. Sample of aggregated display of labels resulting from multiple student groups' tags.

front wall, a multi-touch table, and twenty laptops – all interconnected via high-speed wireless network (Figure 1).

Iteration 1: Aggregated Visualizations in a Math Curriculum

Our original implementation of S3 involved a grade 12 high achieving Math class (n = 19) in an urban high school. Working closely with a Math teacher at the school using a co-design approach (Penuel, Roschelle, & Shechtman, 2007). The curriculum project responded to the math teacher's concern that students did not grasp the interconnections between branches of mathematics, instead perceiving math as consisting of discrete elements (e.g., Algebra, Graphing Functions, Polynomials, and Exponentials) as represented in textbook chapters. Within the S3 classroom students individually logged into laptops, were automatically grouped and placed at one of the room's visualization displays, and asked to "tag" (label) a total of 30 questions. Each group's display showed a graphical visualization of their responses. Students were then asked to collaboratively solve their tagged questions and vote and comment on the validity of other groups' tags. A central display showed a larger real-time aggregate of the all groups' tags as a collective association of links (Figure 2). As students voted on these tags, positive votes resulted in thicker link lines than those that fostered disagreement. As a result of the activity, students' math connections more closely corresponded with those of the teacher. Further, the high variability of students' connections within individual problems (observed during the pre-test) diminished during the curriculum and on a subsequent post-test (Tissenbaum & Slotta, 2009).

Iteration 2: A New Kind of Physics Lesson

Our second implementation of S3 involved two grade 12 Physics classes (n= 32), engaged in a similar form of problem sorting, tagging and solving, but with adaptations that responded to the findings from the from the previous cycle, while extending the design to the domain of physics problem solving. For this design students were sorted into four groups and each student in the group was assigned four out of sixteen total multiple-choice conceptual physics problems to individually solve and tag. Once the first step was completed, students remained in their groups and were shown four of the questions along with the aggregate of the whole class' answers and asked to form a consensus concerning a "final answer" and a final set of tags, along with a rationale for their choices. A final step involved the groups being given a longer physics problem and being asked to choose which of the four provided concepts questions was best suited to helping them solve the longer problem. Findings from this study showed that the accuracy and structuredness of the element tagging by the students working in groups across both classes was closer to the expert model than as individuals. Average accuracy scores were 80.94% (groups) compared to 76.57% (individuals), although the difference was only marginally significant. In terms of structuredness, groups (69.73%) significantly outperformed individuals (50.11%) by 19.62%, $F(1, 30) = 10.756$, $p = 0.003$ (Lui, Tissenbaum & Slotta, accepted).

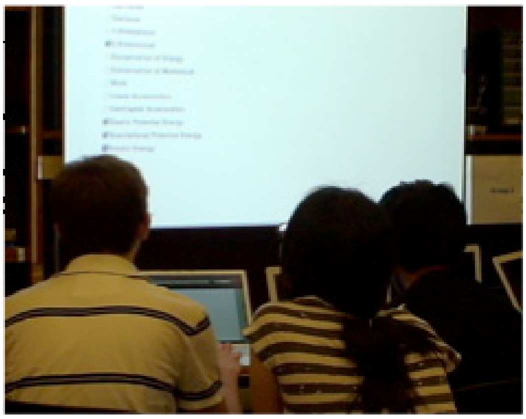

Figure 3. Students selecting elements during the group review activity using the large shared display.

Current Iteration: Real-Time Reporting for Curriculum Orchestration

The current iteration of the S3 environment is similar to iteration two in its content and student grouping, however the curriculum has been extended to include a more complete "teacher portal" for designing and viewing student interactions, and has added informal learning contexts into the initial problem solving stage. The newly designed portal will allow teachers to upload, order, and set the answers for the problems to be used in each run of the curriculum (Figure 4). Teachers can set up multiple conditions for each class or for different classes simultaneously. Unlike in previous iterations, students will now be able to access the individual problem solving activity at home (Figure 5), to be used as a launching point for the next day's activities. All of the individual students answers, reflections, and tags will be collected and uploaded to the server and the aggregate of the students' responses will be available to the teacher at any time (see Figure 6). In this way when planning the next class' lesson the teacher can adapt it to address any conceptual misconceptions the class may have.

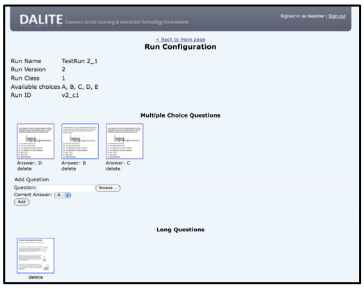

Figure 4. Teacher Design Space.

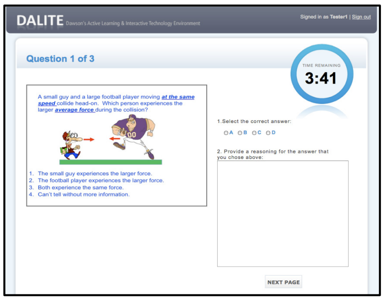

Figure 5. Individual Problem Solving Stage.

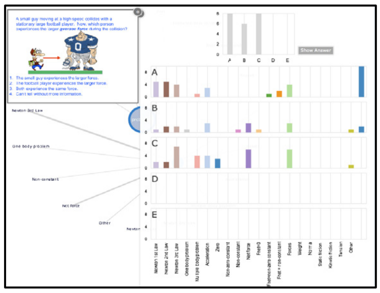

Figure 6. Teacher Visualization.

For the in class activities the system has been adapted to offer the teacher more flexibility within the script to either offer a short, targeted lecture that clarify concepts that students may have shown difficulties with, or to have students go right into the group work activity. Furthermore, the curriculm provides a more opportunities for the teacher to adapt the script between questions based on the real-time reports her or she recieves from the system during the group activities.

Engaging Participants with Current Design

This stage of the presentation will engage the audience in a run through of the current curriculum design – giving them a chance to log in, answer questions individually, and work in groups to form a consensus based on the audience's answers – mimicking an authentic classroom situation. The aggregated product of the audience's answers, using the teacher visualization, will be projected at the front of the room to further simulate an authentic class setting, and will also provide the presenter (playing the role of the teacher) the ability to adapt the script based on the actions of the audience.

Future Developments of the S3 Environment

The final section of the presentation will show case a demo video that highlights where we envision the future development of the S3 environment. The first shows a portion of an extended activity in which the current iteration of Physics problem solving provides the backdrop for an inquiry activity in which the S3 classroom's large screens to display examples of the course content captured by the class in informal settings (such as at home, in the playground, or in the city) using smartphones. Then by using the classroom's touch surfaces, the students collaboratively negotiate correlations between the artifacts and the grounded theory, helping students make a deeper connection between the in-class content and the "real-world".

Questions, Discussion, and Feedback

Note on Format:

We would like to engage one of the teachers who has enacted this curriculum to discuss the different ways in which they have used the curriculum with their students; however, it will largely depend on the time of the presentation as the time difference between Hong Kong and Toronto (13 hours) will make coordination difficult. If this is possible we will fold this portion into the timing of the "Future Developments" and "Question, Discussion, and Feedback" portions of the event.

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