CLASSROOM PRESENTER – A CLASSROOM INTERACTION SYSTEM FOR ACTIVE AND COLLABORATIVE LEARNING

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1. ABSTRACT

In this paper we describe Classroom Presenter, a Tablet PC-based system that facilitates active and collaborative learning in the classroom. In our setup, both the instructor and the students are equipped with tablet computers. At various points during a lecture, students are asked to solve a problem or answer a question. In response, students write their solutions on the tablets and submit them wirelessly to the instructor. The instructor can view all responses, select one or more to display to the class, and annotate responses with ink as they are being displayed. Since Fall 2004 we have piloted the system in eight Computer Science courses at the University of Washington. Here we will describe the system and our initial experiences in the classroom.

2. CONTEXT

Computing technology has the potential to radically change the higher education classroom by increasing access to information and facilitating the sharing of content in real time between students and the instructor. Our goal is to develop the pedagogy and technology that would allow us to address a collection of widely recognized challenges associated with the traditional university lecture. Our specific pedagogical goals are to:

- increase student engagement;
- provide real time feedback to the instructor on student understanding;
- integrate student materials into classroom discussions.

We are targeting classrooms where students have personal computing devices that connect to the instructor's device over a wireless network. The technology to support this, classroom wireless networks and data projectors, is becoming increasingly more widely available and much easier to use. At the same time, many different options for student devices are springing into existence. In the long run, we expect that it will not be uncommon for students to bring their own devices to class, and for the classroom to be transformed into a network of a wide range of platforms and form factors. As a step towards this, we are developing technology around student PCs in the classroom, with particular emphasis on the Tablet PC. We believe that the long term value of student devices in the classroom will come from a combination of the facilities that they provide: access to outside resources and domain specific applications, support for note taking integrated with the instructor's materials, and allowing real time classroom interaction in the context of course content. In our current work, we are emphasizing the latter by developing a system that integrates the instructor's slides with student devices and provides a mechanism for students to annotate and send slides back to the instructor.

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Our project has been guided by several key design decisions. We have emphasized the development of pedagogy in parallel with that of the enabling technology – since it is necessary to adapt one's approach to teaching in order to take advantage of the new possibilities that the technology affords. We have been supporting both internal and external use of the technology, in order to exercise it in a variety of environments and modes, and to benefit from the resulting infusion of ideas. The project has lately concentrated on one key classroom scenario, *student submissions*, which we discuss below.

3. SOLUTION

To support our goals, we have developed Classroom Presenter – a distributed Tablet PC-based classroom interaction system. The system supports sharing of digital ink written on electronic slides. Using a digital pen, the instructor writes on top of a slide on a Tablet PC and the ink appears simultaneously on a public display. This allows the system to be used as a presentation tool, providing dynamicity to traditional PowerPoint-style lectures by enabling ink augmentation of slide content. Classroom Presenter also supports bi-directional sharing of information with student devices. The students' slides can be synchronized with the instructor's slides and receive the instructor's ink in real time. Students can also write on slides and send the resulting artifacts back to the instructor anonymously. We refer to this as the student submission scenario. The instructor can then choose to show some of the submissions on a public display and possibly annotate those using ink. In tandem with instructor-led discussion and ink annotations, we feel that student submissions can be an invaluable pedagogical tool.

Student submissions are central to the pedagogy we are developing around the use of interacting student devices. The instructor develops a slide-based lecture (using a standard tool such as PowerPoint) and includes a number of activities on the lecture slides. When an activity slide is reached, students write their answers on that slide with digital ink and send the slide and ink back to the instructor. The instructor can then review the submissions and selectively show some on the public display. This allows the instructor to incorporate a diversity of ideas, show novel solutions, and discuss misconceptions illustrated by student answers. The use of a public display creates a focus of attention and provides a mechanism whereby student work can be integrated into the lecture discussion – one of the most powerful aspects of the student submission process. Figure 1 shows the instructor interface and the student interface to Classroom Presenter.

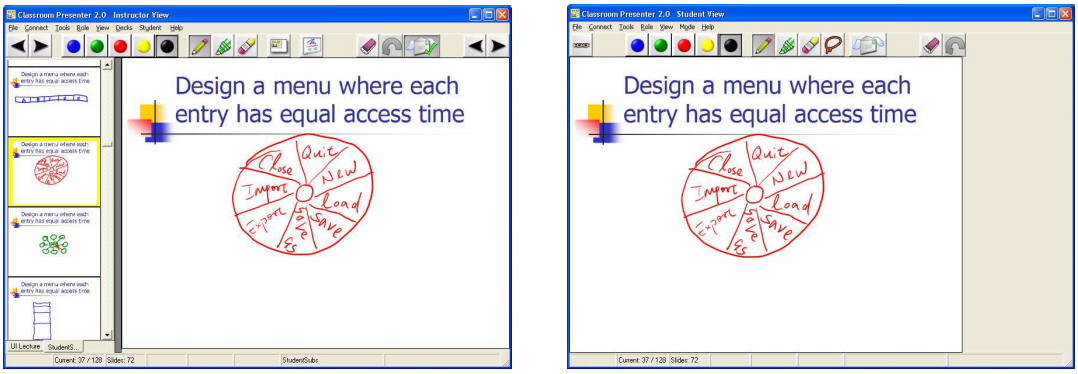

Figure 1. The activity "Design a menu . . ." is shown to the class on the public display and is availed to each student on their Tablet PCs. A student (right) draws a solution and then sends it back to the instructor. The instructor's machine (left) shows the received student submission (along with others) in a film strip, and when the instructor selects it in the film strip, the submission is shown on the main view as well as on the public display.

Although Classroom Presenter is designed to be a classroom interaction system, in many of the current deployments the system is used solely as a standalone presentation aid, taking advantage of the facilities for writing on top of electronic slides with digital ink. We consider the support of presentation to be very important as part of the interaction system, since it provides a smooth transition between lecture style and interaction-based pedagogy. Classroom Presenter has a number of features that instructors find quite useful in a presentation. Among them are the ability to zoom a slide for additional writing space and the controls, designed especially for Tablet-based presentation. Classroom Presenter is also being used in distance learning classes, where the broadcast of digital ink and slides allows the public display to be shown at a remote site.

There are a number of current efforts to extend Classroom Presenter. One of these is Ubiquitous Presenter which replaces Classroom Presenter's broadcast networking with a web service. The advantages of using a web based protocol are that it makes it possible for a far wider range of clients to interact with Classroom Presenter, and provides a reliable (albeit slower) communication mechanism.

We have been piloting the student submission portion of the system on an experimental basis since December 2004 in several junior and senior level undergraduate Computer Science courses as well as in one graduate level seminar. The courses include Algorithms, Data Structures, Software Engineering, Digital Design, and Human-Computer Interaction (HCI). The purpose of these deployments has been to explore uses of the technology and the associated pedagogy it affords. We usually had about 20 HP TC1100 Tablet PCs deployed in the classroom, communicating over an ad hoc or infrastructure-based wireless network. In courses with more than 20 students we generally had students share devices.

4. EVALUATION

Overall, students have responded very positively to the system. In one of the courses surveyed 43 out of 44 students thought the system had a positive effect on their learning experience. 40 out of 44 students felt that seeing other student solutions had a positive effect on their learning, although 20 of these students admitted that they would only have volunteered to show their answers to the class less than half the time if ever. In other courses students made observations such as "it gives equal voice to the quiet person and the one that talks a lot," and "The best thing about this system is it encourages the students to actually work on the problem ... Knowing that my solution will appear on screen but will also remain anonymous encourages me to participate but at the same time reduces the worry of getting it wrong."

We have found that there is usually time to fit four to five activities during an hour-long lecture. During the activities students are almost universally engaged in working on the problems and writing solutions on their tablets. We have also observed individual students becoming visibly excited when their solution is displayed to the class. Next, we address the achievement of the pedagogical goals stated in section 2 by illustrating the discussion with examples of activities from actual classes.

4.1 Increase Student Engagement

Figure 2 shows two sample activities from courses in Algorithms and Digital Design, respectively. In (A), the students were asked to perform a topological sort of a given graph. However, for the particular graph doing this is not possible because of the cycle present in the graph, which the student in (A) noticed. Rather than having the instructor simply tell students

that the sorting was not possible, or having one eager student volunteer the answer before everyone has had a chance to think through it, doing this activity as a student submission gave all students a chance to work through the problem themselves and encounter the difficulty on their own. Because student submissions are anonymous as a rule, even shy students could volunteer a solution. The example in (B) shows an activity where students had to draw a finite state machine. The Canadian flag on the slide was drawn by the student so they could easily identify their work when it was displayed publicly. Since submissions are displayed anonymously, this kind of behavior indicates that students are interested in someone (possibly themselves or their friends) knowing that their solution has been displayed.

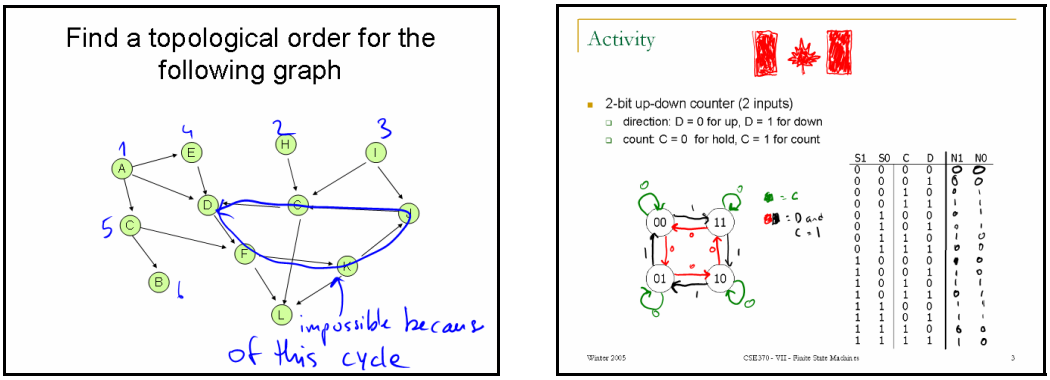

Figure 2. Sample activities where: (A) students discovered an issue on their own; (B) students made use of the expressive qualities of ink to display their personalities in their submissions.

4.2 Provide Real-Time Feedback to the Instructor on Student Understanding

Classroom assessment activities are a natural fit for student submissions. Activities that provide feedback to the instructor about the level of student understanding have been a very common use for the system in our pilot deployments. Figure 3 shows two assessment activities where the instructor posed a question designed to determine if students understood the concept that had just been presented in lecture. Example (A) was used by the instructor to assess whether or not students understood a key operation for a data structure. In the class when this activity was used, about half of the students had the correct solution; the instructor showed one of the incorrect solutions first and explained *why* it was incorrect. The second example (B) is from an activity given at the end of class after the instructor had introduced the concept of distribution functions. Analyzing the submitted responses, the instructor realized that he had failed to convey the essence of the concept clearly.

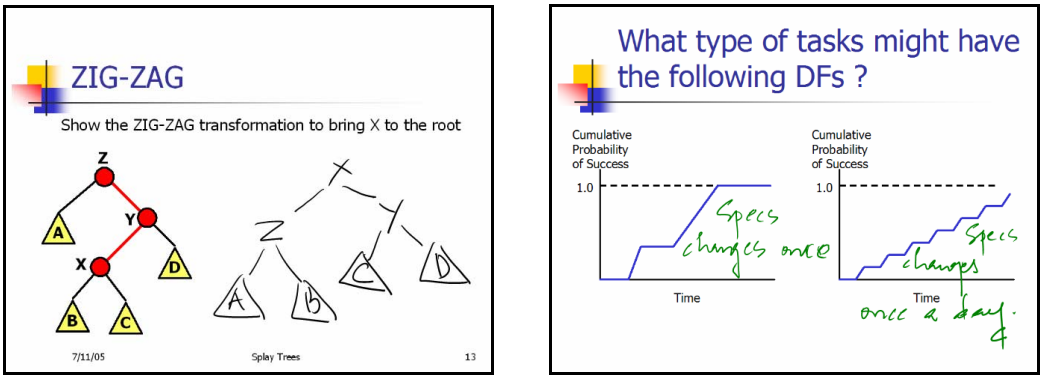

Figure 3. Sample assessment activities from (A) Data Structures and (B) Software Engineering.

4.3 Integrate Student Materials into Classroom Discussions

One of the main goals of the student submissions facility in Classroom Presenter is to provide a mechanism for bringing student artifacts into the lecture discussion. This allows the instructor to use student work to make particular points, or to present misconceptions evidenced in some of the submitted artifacts. Figure 4 (A) shows an example from a lecture about communication structures. There were three specific structures that the instructor planned to discuss, but instead of drawing the corresponding examples himself, he had the students do a submission activity, and then found the desired examples among the submitted work. In the Attention vs. Time example (B), students were to draw a graph showing how attention levels change with time during a traditional lecture class. Although most student answers showed a down slope, they included enough variety that the instructor displayed a number of different submissions to highlight various points.

Including student examples in a discussion has many positive effects. It provides a range of ideas and viewpoints – far more than an instructor can come up with. Student work often carries a "personality" which enhances the classroom atmosphere. Students look forward to seeing their work displayed and discussed, which provides an incentive for them to do the exercises.

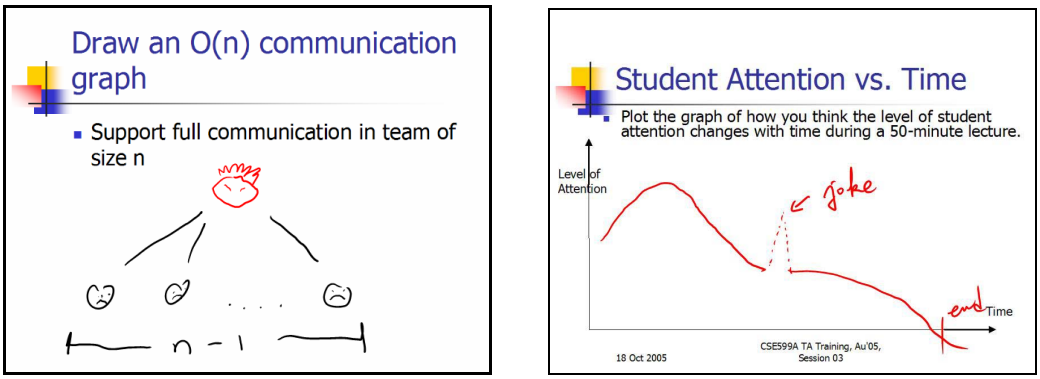

Figure 4. Sample activities from (A) Software Engineering and (B) Teaching Assistant Training seminar.

5. ADDITIONAL RESOURCES

The project website is www.cs.washington.edu/education/dl/presenter/. Classroom Presenter is available for download for educational use from that site. The site also has additional information about Presenter, including our collected papers and talks, a "Getting Started" guide, and a short video. We have a growing collection of Classroom Experience summaries, showing example activities used in actual classes. A mailing list (presenter-profs@cs.washington.edu) is used to communicate with Presenter users[1]. The Classroom Presenter Project maintains close ties with the ConferenceXP Project (www.conferencexp.net) at Microsoft Research, which has supplied the underlying networking technology, and addresses both classroom and distance learning scenarios.

6. ACKNOWLEDGEMENTS

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[1] To be added to the mailing list, send mail to anderson@cs.washington.edu.