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Development of a Tablet-PC-based System to Increase Instructor-Student Classroom Interactions and Student Learning

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1. ABSTRACT

This paper describes a pilot study for a Tablet-PC-based system, called the Classroom Learning Partner (CLP) that is being developed to support in-class formative assessment in large classes. The goal of CLP is to increase instructor-student interaction thereby increasing student learning. This pilot study is a first step: It evaluates the use of Tablet PCs and a Tablet-PC-based classroom presentation system in an introductory computer science class. The presentation system, Classroom Presenter [1], supports student wireless submission of digital ink answers to in-class exercises. In this study, we evaluate the hypothesis that the use of such a system increases student learning by: (1) increasing student focus and attentiveness in class, (2) providing immediate feedback to both students and instructor about student misunderstandings, (3) enabling the instructor to adjust course material in real-time based upon student answers to in-class exercises, (4) increasing student satisfaction. This pilot study evaluates each of the above four parameters by means of classroom observation, surveys, and interviews.

2. PROBLEM STATEMENT AND CONTEXT

Personal interaction between instructor and student in large classes is almost impossible. How can classes become more a two-way conversation between instructor and students? One way is to give students the ability to engage in hands-on activities that yield immediate feedback through interaction with instructors and peers. This technique, termed formative assessment, has proven successful in large and small classes [2]. In large classrooms that employ a wireless polling system called Personal Response System, or PRS, for example, students use a transmitter to submit answers to multiple-choice, true and false, or matching questions. The results are tabulated and displayed in the form of a histogram on the instructor's computer. A system such as PRS provides a way for students to communicate their misunderstandings to an instructor. Instructors, however, are limited to asking questions having pre-existing sets of possible answers, i.e., close-ended questions, which assess recognition rather than recall.

In small classes, instructors can engage the students in a wider variety of in-class exercises than in large classes, since an instructor only has to evaluate a small number of answers. Students can work problems at a blackboard, on paper, or using pen-based computer systems [3, 4]. Can this technique be used in a large classroom, e.g., with 100 or more students, where the logistics of managing very large numbers of student answers could easily overwhelm an instructor?

3. SOLUTION

The Fall '05 term Tablet PC deployment described in this paper is a pilot study for a system, called the Classroom Learning Partner (CLP), that the first author's research group is developing to support formative classroom assessment in large classes. The Classroom Learning Partner (CLP) will support in-class exercises in a large class, while also enabling instructors to use the wide variety of exercises possible in small classes. The key idea: Aggregate student answers into a small number of equivalence classes by comparing those answers to instructor-specified correct answers and incorrect answers, and/or by clustering student answers. Then present the summary information to the instructor, e.g., in the form of a histogram and example answers.

CLP is being built on top of an existing Tablet-PC-based presentation system, Classroom Presenter [1], which supports student wireless submission of digital ink answers to in-class exercises. Using Classroom Presenter, an instructor lectures and annotates slides with digital ink. The slides and ink are displayed simultaneously on a large screen and on students' Tablet PCs. When an instructor displays a slide containing an exercise, the students work the exercise, then anonymously submit digital ink answers to the instructor via a wireless network. Using Classroom Presenter in this way works well in classes of size eight or smaller, as instructors can be easily overwhelmed by more than eight solutions [5]. CLP's aggregation component will enable Classroom Presenter-like systems to be used in significantly larger classes.

With Classroom Presenter, and by extension CLP, instructor and students will interact more often and in a more meaningful way than has been possible to date. They will interact using a teaching technique that increases student learning by: (1) increasing student focus and attentiveness in class, (2) providing immediate feedback to both students and instructor about student misunderstandings, (3) enabling the instructor to adjust course material in real-time based upon student answers to in-class exercises, (4) increasing student satisfaction. This pilot study investigates each of the above four parameters.

4. EVALUATION

In this pilot study we evaluated the above four parameters through classroom observation, surveys, and interviews. The study was run in the Fall 2005 term in an introductory computer science class of 15 students. The results will inform a Spring 2006 study.

4.1 Methodology

1. <u>Students were assigned randomly to the class</u>. This study took place in one of five recitation sections to which students were randomly assigned for an MIT introductory computer science class. With random assignment we did not bias our sample by asking for volunteers, who may have had a predilection for using Tablet PCs. Students in the class attended recitation sections, class size approximately 20, twice a week for 50 minutes; they also attended lecture twice a week for 50 minutes. Students were given the opportunity to switch recitations if they did not want to participate in the study. None switched; one chose not to participate. The students spent the first five weeks in recitation without using Tablet PCs. After the first class exam, they used Tablet PCs in the class for nine of the remaining ten weeks of the term.

2. <u>The Tablet PCs were associated with the class, not with each student</u>. Students had the use of a tablet during class; they were not assigned a particular tablet. We chose not to loan each student a Tablet PC for the term as some researchers have done because: (1) we did not want the

machines to be lost or damaged; (2) we wanted to increase the amount of data collected by making sure machines were not forgotten or uncharged; (3) we wanted to simulate our long term vision of technology: that it is ubiquitous—in the classroom, e.g., embedded in the furniture—and that data and information, rather than technology itself, is of primary importance to people.

3. The instructor used Classroom Presenter; students wirelessly submitted answers to in-class exercises. Classroom Presenter is stable, so that students' experiences would not be colored by frustration with untested software. As software associated with the Classroom Learning Partner is developed, it will be loaded onto the machines.

Each class typically included an initial ten minute review of lecture material and included both student answering and asking of questions; followed by approximately 35 minutes of working in-class exercises, and a five minute summary.

4. Three categories of data were collected. (1) Two surveys, one given at the time the students began using Tablet PCs, the second at the end of the term; (2) multiple timed five-minute observation periods of students; and (3) short after-class interviews with students, which validated or clarified observed learning styles and individual surveys. The data collected related to the students' learning styles and preferences, self-perceptions, and levels of satisfaction.

5. Students saved their work. At the end of each class, students could save their Classroom Presenter slides, which contained both the instructor's ink and their ink. Slides were saved to a USB device or directly to their campus directory; most chose the directory option.

4.2 Metrics

4.2.1 Increase in Student Learning

We assessed the increase in student learning by collecting data on all grades for exams, programming projects, problem sets, the final examination, and class participation for the entire class of 100 students. The results for students in our pilot class were compared to results for students in the other four recitation classes. In addition, we are in the process of correlating student learning with the learning styles, attentiveness, and levels of satisfaction as assessed through surveys, class observations, and interviews. This comparison serves as a good basis for determining how well the Tablet PC may function in our intended large classroom setting.

4.2.2 Instructor-Student Interactions

Our pilot study sought to quantify the following four parameters through classroom observation, surveys and interviews.

(1) Student Focus and Attentiveness in Class: We assessed student focus and attentiveness by timed and sampled observations of the students in class. These observations included the time students spent solving problems or taking notes on class material. This data was contrasted with the amount of time students spent doing non-class related activities (e.g. doodling, surfing the web, etc.).

(2) Feedback to Students and Instructor about Student Misunderstandings: Through classroom observations we assessed the feedback given to students by the amount of time the instructor spent explaining and clarifying incorrect or almost correct answers. This number correlates *ex post facto* with the amount of feedback the instructor received regarding student misunderstandings or the desire for elaboration.

(3) Adjustment in Course Material made by Instructor: We assessed the adjustment that the instructor made based comparing the preplanned presentation of course material with the changes that the instructor made during class and in subsequent recitations.

(4) Satisfaction and Self-Perceptions: We collected data on student satisfaction and self-perceptions through interviews with students done by the second author. We also administered surveys to students both at the start and the completion of the course.

4.3 Preliminary Results and Interpretation

4.3.1 Student Learning

Tablet PCs were not used in the recitation prior to the first exam, which occurred in the fifth week (of fifteen) of the term. The engagement style of teaching that encouraged, enticed, and required student involvement, resulted in 35.7% of students scoring in the top 10% on the first exam, even though the students in this recitation comprised only 15.3% of all students taking the computer science class.

After the first exam, students were introduced to the Tablet PC in conjunction with the Classroom Presenter software. The teaching style that encouraged engagement remained the same, but students also had the added advantage of wirelessly submitting to the instructor digital ink answers to in-class exercises. The instructor displayed a subset of answers for each exercise, giving immediate feedback on correctness and engaging the students in class discussion.

The students in this class performed better than would be expected by chance. They comprised 44.4% of students in the top 10% of the class in final grades—three times greater than expected since these students represented 15.3% of the entire computer science class. The students also were much less apt to perform poorly: Only 8.3% of these students placed in the bottom 25% of the entire class. The expected percentage again was 15.3%. Further, no student received a D or an F.

4.3.1 Instructor-Student Interactions

(1) Student Focus and Attentiveness in Class: Fourteen of sixteen students spent over 90% of class time focused and attentive to classroom material. The remaining two students spent 80%-85% in the same manner. Deviations from focus and attention reflected two factors. First, some students were bored because they knew the material extremely well and did homework instead. There were only six observed incidents when one, two, or three students used their Tablet PCs for unrelated work. Students, thus, were focused and attendant to material presented. A basis for comparison with other similar classes was not made.

(2) Feedback to Students and Instructor about Student Misunderstandings: Seventy-five percent of the class time was spent providing feedback to students in response to written answers submitted to problems and verbal questions related to these problems. All students whose grades placed them in the middle third of the class reported that feedback helped them. The top third of students primarily benefited only on the relatively few problems on which they had difficulty. The bottom third also benefited but often felt that they needed more time spent on the answers that they did not understand.

(3) Adjustment in Course Material made by Instructor: The instructor placed emphasis on responding to student misunderstandings, which were evident from incorrect submitted answers or oral questions. She postponed introduction of new in-class exercises in three of thirteen

recitations in order to spend more time on misunderstood concepts. The postponed exercises were either presented in the following recitation or posted as practice exercises on the instructor's website. In two recitations, the instructor introduced new, more challenging exercises because all submitted answers to preplanned exercises were correct. The instructor, thus, presented both preplanned and extra exercises, while also responding to all student questions.

(4) Student Satisfaction and Self-Perceptions: Student satisfaction was extremely high, but can be more precisely analyzed when based upon level of performance in class. The top third of the students perceived the computer science course to be much easier than anticipated because they were able to get immediate feedback in recitation on the few questions that caused them difficulty. The three students who felt that they did not benefit from the use of the Tablet PC had the bottom three grades in the class. (These students may have benefited, however, since their grades were 1 B and 2 Cs.)

5. FUTURE WORK

Our results indicate that student learning seems to be positively affected by the use of engagement strategies, the Tablet PC, and the Classroom Presenter software. The feedback mechanism in particular has been beneficial. Three more Tablet PC deployments are planned that incorporate what we have learned from this initial study. In Spring 2006, the first author will teach two sections of the introductory computer science class, one with Tablet PCs, one without. CLP will be deployed in the Tablet PC class. We will compare the use of aggregated student answers in Spring 2006 with the use of unaggregated student answers. In academic year 2006-2007, the system will be deployed in a lecture class of 200 students.

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