MOBILE TECHNOLOGY AND CORE COLLEGE MATH

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Introduction

Too often freshman fail and fall behind early in their first college math course, such as Calculus for Engineers (MthSc106) or Liberal Arts Math (MthSc101), because they do not engage in the classroom and their questions remain unanswered. Much research has focused on the importance of success in the first college math course, not only with its correlation with retention rates in STEM fields, but also with retention rates in the university [3].

By means of a 2006 Hewlett-Packard "Teaching for Technology" Grant, we inserted HP Tablet PCs and projectors into in twelve sections of both freshman Calculus and Liberal Arts Math. With this implementation, individual students or groups of students submit problem solutions anonymously via electronic ink to the instructor at various points throughout the class which are then projected, discussed, annotated, and saved. This classroom interaction takes place via web-based software, either *MessageGrid* or *Ubiquitous Presenter.*

Tablet PCs allow active learning to be achieved in the classroom because an instructor is able to teach a new concept in a context that has meaning for the student—e.g., the student is working on his own or with others to solve a problem and receives immediate feedback from the instructor. Moreover, communication now occurs with that subset of students who would rarely participate in class.

Math for Liberal Arts

Because data from the Spring 2007 Calculus sections is still being collected, this paper analyzes the use of Tablet PCs in conjunction with classroom-interaction software in the Fall 2006 sections of Mathematics for Liberal Arts.

The traditional offering of MthSc101 (Mathematics for Liberal Arts) is a 15-week course that meets two times a week for a 75-minute lecture (19 students per graduate instructor; up to 35 students per full-time instructor). The traditional course has no computer component. Each instructor assigns weekly credit homework and quizzes. There are three common exams and a comprehensive common final exam.

In Fall 2006, we organized 5 HP Tablet PC-based sections of MthSc101, each containing 19 students, with an HP Tablet PC for each student. Instructors in both the traditional and Tablet-PC sections are encouraged to lecture for no more than 15 minutes on new material before allowing students to try problems. In the traditional sections, instructors may put problems on the board for students to try, or hand out worksheets. In the Tablet-PC

sections, students are asked to work problems that appear on their screens and submit solutions which then appear on the instructor's PC where he can project and discuss them.

To make the two versions of the courses as comparable as possible, experienced instructors and first time graduate instructors teach both Tablet PC and non-Tablet PC sections. Final grades are calculated the same way in all sections and common exams are given. Attendance is taken in all sections. All sections have access to a course website that posts copies of old exams, copies of worksheets used in the Tablet-PC sections, and supplemental reading materials.

It was not possible to randomly assign students to the two courses; they were allowed to self-select sections. However, the Tablet-PC option is not mentioned in the general catalog, and students would not have heard about it from their academic advisors, as it was organized by the math department in late summer.

Classroom-Interaction Software

The web-based software program, *MessageGrid,* was developed at Clemson University in 2004 [2]. It enables classroom interaction by allowing students to ink their submissions into a large grid, where the questions might be in columns, and the student responses in rows. The instructor can then scroll down a column, enlarge a particular submission, and annotate someone's correct or incorrect approach to the problem. *MessageGrid* is easy to learn and involves no registration procedure. An instructor simply adds his students' web addresses to the list of Users. Students access the Grids for their class from the internet using their university ID.

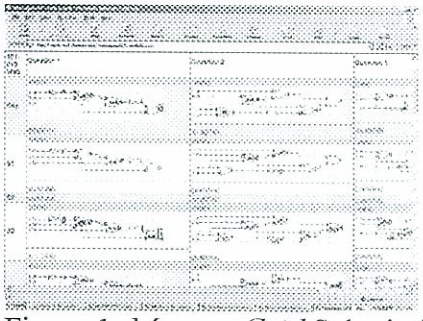

Figure 1. *MessageGrid* Submissions

Ubiquitous Presenter (UP) was developed in 2005 at the University of San Diego as an outgrowth of University of Washington's *Classroom Presenter* (CP). It uses Tablet PC ink to allow instructors to annotate pre-prepared PowerPoint slides and upload them to a location on the web where students can then create submissions for in-class activities. The instructor sees a list of student submissions to the left of his screen and can enlarge any one of them by clicking on it:

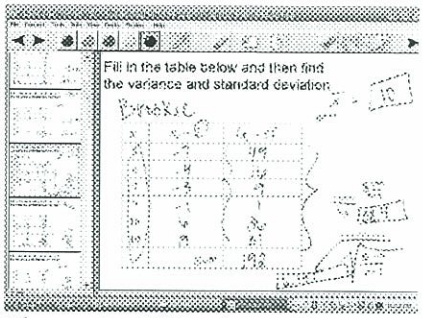

Figure 2. *Ubiquitous Presenter* Submissions

All student submissions and teacher annotations are saved, whether attached to the grids or to the PowerPoints, at a location on the web that can be accessed and reviewed by the students from any computer outside of class.

Evaluation Method

This project measures a number of variables in four categories:

(1) *Initial student comparability variables:* We examine a number of potentially confounding variables in each section of MtheSc101 and MthSc106: Grade-Point Average (GPA), Class standing (Freshman, Sophomore, etc.) and score on the CMPT (Clemson Mathematics Placement Test).

(2) *Performance Measures:* Detailed statistics are kept on each section of MthSc101 and MthSc106. We track the improvement in retention and performance (DFW rate) in the 16 sections using Tablet PC technology over two semesters. Since there are 3 or 4 common exams and a common final each semester, we look closely at these results and compare these results with the other sections of this course. Also, we will be able to track the success of students in MthSc106 as they move into the sequence course, MthSc108.

(3) *Student behaviors and satisfaction.* We administer three inventories throughout the semester. Among other things, we asked the students to rank their sources of learning in this course: lecture, text, Tablet PC interaction, paper or electronic worksheets, electronic quizzes, homework, journals, etc. Perceptions change as everyone becomes more adept with the software, hardware, and the routine.

(4) *Instructor investment of time, expectations, satisfaction.* Attitudinal surveys are given to assess faculty perceptions of using the technology in MthSc101 and MthSc106.

Performance Results

Results on the Common Exams for the 5 Tablet PC sections were compared with the 22 non-tablet sections. The mean scores in the Tablet PC sections were consistently 2-3 percentage points higher than in the traditional sections (using a one-tailed t-test for independent samples with unequal variances; Table 1).

This is surprising for two reasons: (1) More than one week of classes was spent on

acclimating faculty and students to the new hardware and software. Time was lost on teaching the course material. (2) The class profile was almost identical for the Tablet PC and the Traditional sections (see Table 2). The average scores on the CMPT (Clemson Mathematics Placement Test), the average GPAs (Grade Point Averages), and the number of freshmen did not confer any advantage on the Tablet-PC sections. (There is, not surprisingly, a correlation between GPA and Final Grade (r = .853).)

Table 1. Performance comparison of Tablet PC and Traditional sections on Common Exams.

Variable	Descriptive Statistics	Tablet PC MthSc101 N=90	Traditional MthSc101 N=437
Exam 1 (%)	Mean S.D.	88.37 10.30	85.54 12.32
Exam 2 (%)	Mean S.D.	77.13 18.73	75.32 18.29
Exam 3 (%)	Mean S.D.	80.95 10.54	77.58 14.41
Final Exam (%)	Mean S.D. t df p	79.01 12.76 2.298 135 <0.012	75.46 15.01
Final Grade (%)	Mean S.D.	83.11 11.75	80.58 13.38

Table 2. Class Profiles.

Variable	Tablet PC MthSc101 N=97	Traditional MthSc101 N=437
CMPT (Total possible = 50)	28.78	29.2
GPA (Total possible= 4.00)	2.96	3.03
Class Standing Freshman (%)	76.66	77.80

Two of the instructors (S. Samson and M. Reba) taught both a Tablet PC section and a traditional section of MthSc101 in Fall 2006. Contrasting the performance of their students in both sections, we find that each instructor had mean scores on their final grades that were 6-11 percentage points higher in their Tablet-PC sections, given a class profile very similar to the class profile of the traditional sections. One of Reba's traditional classes had more students which is a variable that affects these results, and in Spring 07 we are looking at the impact of Tablet-PCs in larger sections. (See Table 3.)

Table 3. Same Instructor /Different Sections.

Variable	S. Samson		M. Reba	
	Tablet PC MthSc101 N=19	Traditional MthSc101 N=19	Tablet PC MthSc101 N=19	Traditional MthSc101 N=32
Final Grade Mean S.D.	 81.21 11.15	 75.95 16.55	 84.63 9.54	 73.54 15.4
CMPT Mean	 30.13	 28.94	 27.69	 28.26

S.D.	.73	.94	.99	.77
GPA				
Mean	1.94	2.47	2.94	2.74
S.D.	3.12	2.41	1.84	1.82

The DFW rate (Poor-Failing-Withdraw) in all sections of MthSc101 was 19% in 2005-06 and dropped to 13% in Fall 2006. Though the DFW in the tablet PC sections was slightly lower (12%), since the reduction in the DFW rate was seen across several undergraduate courses, it might be explained by a freshman class with higher academic qualifications than in the previous year.

Behavior and Satisfaction

In the Tablet-PC sections, a midterm and final survey revealed approximately 90% of the students described themselves as actively participating in class (as opposed to 25% in the traditional sections) and also cited their primary learning source as the pen-based/ computer activity sheets (as opposed to textbook or quizzes). Perceptions by instructors teaching the Tablet-PC sections were positive, despite the time spent on learning the technology and at extra meetings. Everyone opted to teach with the Tablet PCs for another semester (Spring 2007) and with more students per class.

Future Directions

This Spring 2007 we are working with the Tablet-PCs in the 4 SCALE-UP Calculus Classrooms with up to 45 students per section, as well as in 4 sections of Liberal Arts Math, some with up to 35 students per section.[1] Students now work in teams of two or three with the Tablet-PCs. In Fall 2007, we plan to expand the use of the Tablet PCs into more sections of Calculus, and to work collaboratively with the Roy Pargas and his team in the Department of Computer Science at Clemson University to enhance *MessageGrid* as a software tool as it relates to Calculus instruction.

In developing digital Calculus materials for use with Tablet-PCs and classroom interaction software, we hope to save instructors time, provide incentives for using this technology, and to offer a blueprint for how this technology might be used in other mathematics or STEM courses.

References

[1] Beichner, R. "Student-Centered Activities for Large-Enrollment University Physics (SCALE-UP), Principle Investigator, NSF Award 9981107.

[2] Pargas, R. P, and J. Austin. "Work in Progress: Providing Interactivity in a Technology-rich Classroom," Proceedings of the 2005 ASEE/IEEE Frontiers in Education Conference, 13-15.

[3] Seymour, E. and N. Hewitt. Talking About Leaving: Why Undergraduates Leaving the Sciences, Westview Press, Boulder, CO, 1997.