AC 2007-114: INTEGRATION OF TABLET PCS INTO COLLABORATIVE LEARNING ENVIRONMENTS

Jeff Frolik, University of Vermont

Integration of Tablet PCs into Collaborative Learning Environments

Introduction

This paper presents the results of a project, ongoing since Fall of 2004 at the University of Vermont (UVM), in which university-owned, Tablet PCs have been integrated into learning environments where engineering students collaborate most frequently: namely, in laboratories and design courses. The primary objective of this work was to ascertain how mobile, pen-based computing can enhance both individual and team learning in these settings from both student and faculty perspectives. The working premise was that Tablets have added benefit, in comparison to laptops, since much engineering content consists of equations and diagrams, entry of which is cumbersome at best with a keyboard and/or mouse. A secondary objective was to ascertain how students would adopt and adapt to this new computing platform. Three distinct studies are discussed in the following pages.

Study 1: A First-Year Engineering Design Laboratory

Since Spring 2005, Tablets have been utilized in the laboratory section of a first-year engineering design course. This course is a requirement of our electrical and mechanical engineering majors. To date, ~250 students have utilized Tablets for a variety of laboratory activities as discussed below.

Implementation

Students have used, under direction, Tablets for a variety of tasks including project brainstorming (pen-entry using Journal), CAD design (Solid Works), technical communications (PowerPoint), data acquisition (MeterView), and data analysis (Excel). The availability of this mobile platform also enabled laboratory procedures to be restructured as Tablet-based, PowerPoint presentations (vs. printed documents) with embedded detailed photographs, Internet links, etc. For example, one exercise requires students to assemble a simple wireless temperature sensor. As illustrated in Fig. 1, the Tablets enabled the students, working in pairs, to self-pace through the circuit's assembly. Detailed pictures of circuit throughout its build are clearly represented in the screen images and further descriptions of components are included. For example, this particular circuit utilizes a 555-timer integrated circuit for which simulations are embedded in this assembly 'manual'.

Figure 1. Students utilizing electronic assembly manuals enabled by Tablet mobility

Students also work in teams on interdisciplinary design projects and continue to use Tablets for similar tasks but in an ad hoc manner. For example, as part of their design projects some of the team members were responsible for CAD drawings of parts which were submitted for rapid prototyping fabrication. Due to the mobility of the Tablets, we were able to hold impromptu help sessions by clustering students with their working CAD drawing. We also observed student teams working in clusters where one student was developing project action items in Journal, another student was working in CAD, another searched online for parts, while another was building a circuit.

Results

Students have readily accepted and taken full advantage of the mobility enabled by Tablets. The ability for students to collocate while working on different computing tasks improved the communication between students and overall effectiveness of their collaboration. While students noted the mobility enabled by Tablets, the general view gleaned from an end of semester survey was that there was little value added by the pen-based entry feature. This is not too surprising given the majority tasks for which the Tablets were used for (e.g., CAD, electronic assembly manuals, etc.). However, several attempts were made to encourage use of the pen-based feature. For example, student teams were asked to document their project brainstorming activity using Journal. However, this exercise was viewed by both the students and faculty as being less effective in comparison to using whiteboards, poster paper or simply notebook paper.

Study 2: Telecommunications Lab Course

In Fall 2004 and Fall 2005, students enrolled in this senior-year elective were provided a Tablet PC for use in and out of class for the duration of the semester. During this study, ~18 electrical engineering students utilized the Tablets under the scenario described below.

Implementation

This course consists of both a lecture and a laboratory section. For the lecture section, the instructor developed notes in Journal which were posted in advance of class. In class, the instructor would develop a new set of lecture notes in Journal. As was found in our earlier work [1], this method is superior to reading through existing notes for the following reasons. First, writing notes ensures a well-pace lecture. Second, writing the notes enables flexibility in what is presented and enables one to easily address student comments/questions. Finally, writing the notes engages students who prefer to take notes. Other advantages of a Tablet-based, presentation approach, also recognized in subsequent studies [2, 3], include ability to face students while lecturing, having an electronic record of all material presented in class, and the ability to annotate figures. In regards to the latter, many of the images in this course were screen captures from test equipment. Annotating these in Journal was found to be an effective way to demonstrate how these results can be interpreted. As noted, students had a set of notes available prior to class. Using their Tablets, students could annotate these notes with their own comments or with new content provided in class.

For the laboratory section, student teams performed their experiments at times convenient to their schedule and as such there was no real-time oversight to ensure the laboratory exercises were being performed correctly. This problem was addressed, in part, by providing procedures as Journal documents that were embedded with images of sample results; e.g., images captured

off oscilloscopes and spectrum analyzers illustrating the time and frequency-domain representations for different modulation schemes. Students recorded their findings using the Tablet's pen to edit this document (Fig. 2). These findings included numeric results, sketches of observations, annotation of embedded images and written comments. This variety of data types are more intuitively collected through pen as opposed to keyboard and mouse.

Figure 2. Students recording findings in Tablet PC-based laboratory procedures

Upon completion of the laboratory experiments, the students forwarded a copy of the laboratory procedure edited with their findings to the instructor. Through a quick review of these notes, the instructor was able to ascertain whether the experiments had been performed correctly and whether the fundamental concepts were understood sufficiently before students began their formal reports. The instructor returned a commented version to the students. This methodology enabled an electronic 'original' version of the experimental results with instructor comments to remain with the instructor and to be provided to all members of the team. This document can therefore be used by the instructor as a baseline when grading the final reports.

Results

The utilization of the Journal-based laboratory notes has been very successful in ensuring that students have performed their experiments correctly. Having this document in electronic form reduced the feedback time and thus enables student to complete their formal write-ups in a timely and more effective fashion.

From a student's perspective, the following was gleaned from an end of course survey. First, most students utilized the Tablets in all their classes that semester even though this laboratory course was the only one designed to take advantage of this platform. Second, students used the Tablets primarily for note taking in other classes and particularly appreciated the ability to annotate documents and search their text. Third, these students perceived that the pen-based entry capabilities of Tablets had added value in comparison to a laptop. Typical responses noted that monetarily, the pen-based entry was worth an additional $100-$200. Fourth, students indicated that they would encourage incoming freshman to consider a Tablet over a laptop. A few disadvantages were also noted. The particular platform was found to be lacking in not having a CD drive, larger keyboard and screen, and longer battery life. Also, students admitted to using the Tablets for non-class related activities during class (web surfing and games).

Study 3: Wireless Sensor Networks Course

As with the previous study, students taking this senior/graduate elective were provided a Tablet PC for use in and out of class for the duration of the semester (Fall 2006). Thirteen senior/graduate-level students from electrical engineering and computer science participated in this course. Their use of Tablets for classroom work and projects is discussed below.

Implementation

The class was primarily a lecture-based course introducing students to the various research areas being pursued in the field of wireless sensor networks. Much of the material covered in the course was from technical journal papers which were posted online as PDF documents. As with the previous study, instructor notes were developed in Journal and also posted in advance of the lectures.

In addition to the lecture component of this course, students deployed wireless sensors for monitoring applications of their own choosing. The Tablets were found to be a convenient platform for this purpose. As illustrated in Fig. 3, the Tablet could be configured as a slate (keyboard removed) and still enable full data acquisition functionality. In the deployment illustrated, the student is triggering the data acquisition. Upon the triggering, the Tablet's covering was closed and the system began its operation. In short, this form factor was found to more convenient than trying to configure and protect a laptop for such a field study.

Figure 3. Tablet PC being utilized as a data collection platform for a wireless sensor network monitoring greenhouse conditions

Results

While use of Tablets in this course was not required, of the thirteen students, twelve of the students consistently took their notes with the Tablet in this class. Students noted that the Tablets were especially useful in reviewing and electronically annotating the technical papers as they were discussed in class (recall these papers were provided in advance in PDF format).

The vast majority of students reported that they utilized the Tablets in all their classes for note taking (some students taking upward of 500 pages of class notes by midterm) and for their homework assignments. Common comments included the ease at which equations, symbols and graphs can be created and inserted in other documents. In addition, students who served as teaching assistants noted they graded assignments electronically using the Tablet's pen capabilities. Unanimously, students reported their experience with the Tablet over the course of the semester to be useful and the majority regretted having to return their machine. In comparison to a comparable laptop, the pen-based entry feature was gauged to be worth an added ~$200-$300 by this group of students.

Finally, this class was specifically asked what would be required to make Tablet use more attractive in a university setting. First, students repeated the shortcomings listed earlier in regards to the Tablets themselves (needing a CD drive, larger keyboard/screen, longer battery life). Second, students noted that more instructors needed to embrace the technology and to be trained in its effective use. Third, students indicated that the campus wireless infrastructure needed to be improved (e.g., wireless was not available in the rooms used for this course).

Conclusion

Herein, we have presented results of an investigation in which Tablet PCs were utilized in three different learning environments. In the first study presented, where students had access to Tablets only during class time, students took full advantage of the Tablet's mobility to enhance team collaboration. However, for the most part the pen-based entry capability was not viewed by students as especially beneficial. It is worth noting, that the Tablets were shared by students for most of the laboratory exercises in this study. In short, we view that the shared use of *mobile computing* reinforced collaboration among first-year students but at the same time did limited the effectiveness of pen-based activities. However, our subsequent studies do show that individual learning methods are indeed enhanced using this unique feature of Tablets.

In the second and third study, students were provided their own Tablet for the duration of a semester. In these two studies, students fully adopted the pen-based entry provided by Tablets as a means of taking notes, completing assignments and accessing online material during class. In these studies, the majority of students reported using the Tablets in all their courses. Key in this finding is that faculty (with the exception of the author) did not encourage (or were often not even aware) of this student behavior. As such, these findings indicate that Tablet technology may indeed be a computing platform that students will carry with them (even if not required). This result contrasts with student use of laptops in the engineering classroom, which unless required, rarely occurs due to a variety of reasons that have been long reported [4]. As such, Tablets may indeed enable engineering programs to effectively bring computing into the classroom. To see if this is indeed the case, the reader should follow with interest the pedagogical innovations that will (or will not) be made at institutions that have adopted a Tablet PC requirement for their engineering students (such at Virginia Tech beginning in Fall 2006 [5]).

Acknowledgements

This project was enabled by a HP Technology for Teaching (TfT) grant which provided the HP TC1100 Tablets for student use. Additional support was provided through a Microsoft Research Tablet PC Technology, Curriculum and Higher Education award and UVM's Instructional Incentive Grant program. Additional thanks to MicroStrain, Inc. of Williston, Vermont for generously supporting a wide range of wireless sensor related activities at UVM.

Bibliography

[1] J. Frolik and J. Zurn, "Evaluation of Tablet PCs for engineering instruction and content development," ASEE Computers in Education Journal, Vol. 15, No. 3, July-September 2005.

[2] J. Cimbala, R. Toto, M. Wharton and J. Wise, "One step beyond: lecturing with a Tablet PC," 2006 ASEE Annual Conference, Chicago IL.

[3] S. Brophy and G. Walker, "Case study of the pedagogical impact of Tablet PCs as a presentation medium in large-scale engineering classrooms," 2005 ASEE Annual Conference, Portland OR.

[4] J. Griffioen, W. Seales, J. Lumpp, "Teaching in realtime wireless classrooms," Frontiers in Education Conference, 1998. FIE '98, Volume: 2 , Page(s): 748 -753.

[5] L. Nystrom, "College of Engineering to require convertible Tablet PCs for freshmen," Virginia Tech News, April 20, 2006.