TEACHING WITH TABLET PC'S

Kenrick Mock
University of Alaska Anchorage
Anchorage, AK 99508
kenrick@acm.org

ABSTRACT

Tablet PC's are traditional notebook computers with the ability to process digital ink by writing with a stylus. They have recently attracted attention as a potential tool for educational use. This paper describes the author's experience using the Tablet PC to conduct a CS1 course and a software engineering (SWE) course. The SWE course consisted primarily of PowerPoint lectures while the CS1 course consisted primarily of hand-written material. For both courses the Tablet PC was used in the classroom as a digital whiteboard by connecting it to a data projector. The lecture material was archived and accessed electronically for future reference by the students. To capture real-time gesturing and audio commentary, the CS1 course was recorded using screen capture technology. Outside of the classroom, the Tablet PC is also a useful tool for grading, creating lecture material, and capturing meeting notes. Student feedback regarding use of the Tablet PC has been extremely positive.

1. INTRODUCTION AND PREVIOUS WORK

The Tablet PC represents the computer industry's latest attempt at pen-based computing. Since their release in 2002, Tablet PC's have slowly gained attention as a useful tool for educators. The machines are currently in their second to third generation and now contain enough computing power to put them on par with relatively powerful desktop machines. An "official" Tablet PC, as designated by Microsoft, is essentially an x86-based notebook with an active screen digitizer running Windows XP Tablet Edition. This is a variant of Windows XP with add-ons to support pen-based input. Digital ink that is input by pen can be stored directly as ink or recognized as text. As a Windows XP machine, the Tablet PC has the benefit that it can directly execute any program that runs on a standard Windows machine (e.g. PowerPoint, Word) without needing a translation step as required on many PDA's. Models are available today in "slate" and "convertible" form. The slate is a form factor that looks like a large PDA with a separate detachable keyboard. The convertible looks like a traditional laptop except the screen may also be swiveled 360 degrees and turn to lie flat on the keyboard to become a slate.

The Tablet PC is typically used in the classroom as a presentation device that takes the place of the blackboard. Video is output to a screen using a data projector. With products such as Microsoft OneNote, PowerPoint, or Journal, an instructor has the ability to prepare lecture material in advance or write "on the fly" during class as one would write on a blackboard. The latter is particularly useful for material that requires interaction – e.g. illustrating how to solve equations or illustrate dynamic processes that may be difficult to prepare in advance through a medium such as PowerPoint. It is also easy to switch between other computer applications – e.g. a web browser, telnet, or an integrated developer environment.

A number of universities have adopted pilot projects to study the efficacy of Tablet PC's. For example, Notre Dame and Seton Hall University have put Tablet PC's into the hands of faculty to examine their impact as a teaching tool [2,8].

Bentley College distributed Tablet PC's to students [3]. MIT students used Tablet PC's to creatively and collaboratively design robots for the International Design Contest [4]. Individual faculty at numerous institutions have also used Tablet PC's to deliver their courses.

Faculty at the University of Washington have developed the "Classroom Presenter" system based upon Tablet PC's. The system allows an instructor to lecture from a Tablet PC that communicates wirelessly with a server connected to a data projector. This allows the instructor to roam freely about the room and even into the audience, like a TV talk show host, and allows students to write comments that are visible to everyone in the class. Surveys indicated that students paid more attention, understood material better, and encouraged other faculty to also use Tablet PC's [1]. The Classroom Presenter system was extended by Simon, et. al., to put Tablet PC's into the hands of all students in the class so that they can submit ink-based material to the instructor and the instructor may choose submissions to display on the projector. This allows greater collaboration and active learning within the classroom [7].

2. EXPERIENCES USING THE TABLET PC

2.1 Classroom Presentations – CS1

In the spring of 2004 we used a Tablet PC to deliver classroom presentations for a CS1 course. This was a first course in Java programming. Prior to delivery via a Tablet PC, the course was conducted primarily by writing on the blackboard. A computer was used occasionally to demonstrate applications such as an IDE or a debugger. The instructor preferred hand-written delivery over a medium such as PowerPoint in order to slow down the classroom pace and highlight key points of code or design as they were written on the board in real-time.

The major use of the Tablet PC in this course was to replace the blackboard with the tablet. The machine was connected to a data projector and Microsoft OneNote was used in place of the blackboard. This alone presented numerous advantages over the blackboard:

- The lecture can be conducted entirely by drawing in digital ink without preparing material in advance, as is necessary with PowerPoint. Alternately, material can be prepared in advanced and annotated during the lecture.
- The instructor can easily re-display previously covered material that would normally have been erased on a blackboard.
- Convenient access to multiple pens in different colors, widths, and styles
- Easy to switch to other applications (e.g. telnet, web browser, IDE)
- Digital ink can be saved and viewed later through a web browser.
- By standing off to the side, the instructor never occludes the screen and can maintain eye contact with the audience while lecturing.
- No messy chalk or nasty fumes from dry erase markers.

A sample screenshot taken from the CS1 course is shown in figure 1. In this figure a snippet of code was prepared in advance and annotated during the class. A common technique employed by the instructor was to use "attention marks" to draw attention to a specific item. These were often necessary because the cursor in ink mode is a small dot that is not easily visible until something is drawn.

Figure 1. Lecture delivery using the Tablet PC to annotate code.

Annotation is not limited to OneNote or Journal. We used the M2Screen annotator tool that allows anything on the Windows desktop to be annotated. Figure 2 illustrates annotation of code that is overlaid on a window from the NetBeans IDE. The annotation tool acts as a virtual transparency for the desktop. The overlay is toggled on or off from the system tray.

Figure 2. Annotation over a Windows application.

Despite the advantages, there are also a number of disadvantages to Tablet PC-based delivery:

- To project correctly, the tablet must be placed in landscape mode instead of the more comfortable portrait mode.
- Real estate for drawing is smaller than what is normally available in a classroom with a large blackboard.
- Right-clicking is sometimes tricky using the pen.
- Poor display angles for some models.
- Need and expense for a data projector and the Tablet PC.

2.2 Viewing Archived Content

Many instructors using Tablet PC's are saving their lectures to disk and making them available for online viewing. Students are then able to review the material at

their convenience. Microsoft OneNote provides the option to store a page of written notes as a .mht file for viewing in a web browser. Microsoft Journal files may be viewed on non-Tablet PC's using a free viewer. Both approaches save the ink that is drawn in the application into a static document. While this is useful for some material, this approach does not create useful content for lectures that rely on more ephemeral data. Most importantly, crucial audio and gesture information is lost [6]. For example, consider the static archived lecture material shown in figure 3:
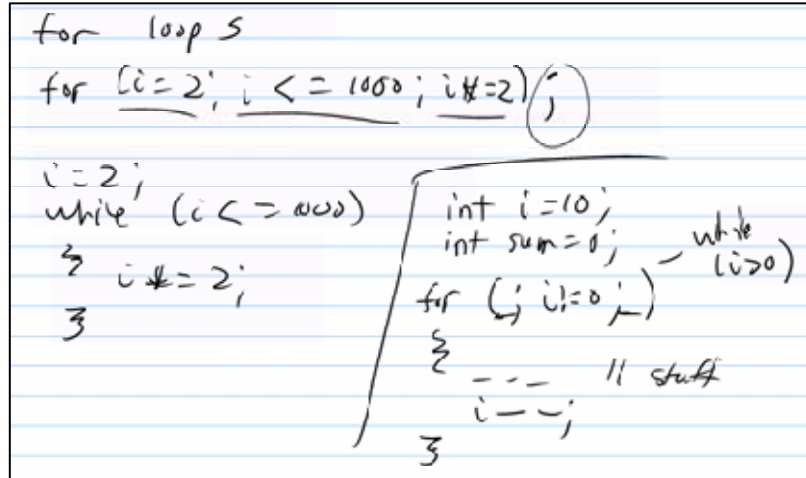

Figure 3. Static, archived lecture material.

What does the circle mean? What is the significance of the underlined material? All of these marks are explained in the actual lecture, but such information is lost in the saved document. As a result, the saved document is largely unintelligible.

To address this problem one solution is to capture the screen and audio into a movie file. We used TechSmith's Camtasia Studio to capture the screen and audio into an AVI file. The AVI video file was then converted into Flash format and linked to the course web page. The Flash conversion compressed the video file considerably and also made the video accessible to a wide variety of browsers. An additional advantage of this technique is that all computer applications are captured, including demonstrations such as web browsing or debugging with an IDE.   Sample video recordings from the course are available for viewing at http://www.math.uaa.alaska.edu/~afkjm/cs201/calendar.html.

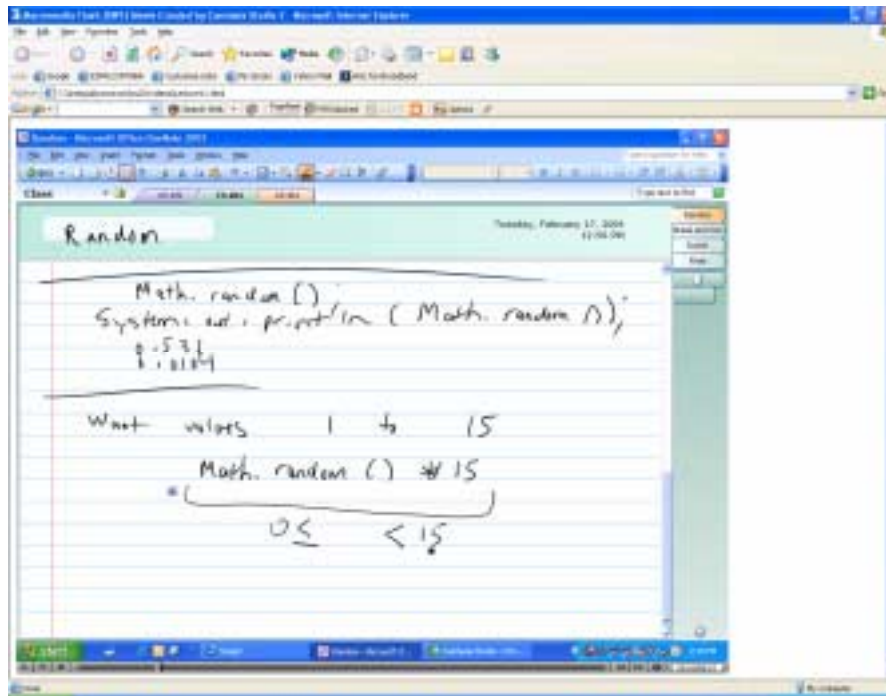A sample screenshot of a recorded video is shown in figure 4.

Figure 4. Archived Flash video of lecture

The greatest disadvantage of this approach is the large size of the recorded video file. Our experiences indicate that a 1 hour lecture requires approximately 20 Mb of storage using lossless encoding in the Flash format at 3 frames per second and 1024 by 768 resolution. Significantly better compression is possible using lossy techniques such as the Windows Media format, but some artifacts result, particularly with photographs and non-textual material. The degradation in quality does not appear to be significant for our application, since we are using primarily text and ink, but we decided to stick with the lossless technique for greater quality and flexibility for situations where we may wish to record images or detailed graphs.   As a result, the large file size makes viewing difficult through low-bandwidth connections such as 56K modems. However, we did have lab machines available that students could use to view the videos at high speed.

Another disadvantage is the relatively low audio quality of the built-in microphone.   The built-in microphone captured the instructor's audio as long as he was close to the machine, but the computer's fan would sometimes create annoying background noise.   Moreover, questions from the students were not audible in the recording. We intend to address these problems in the future by using an external microphone instead of the built-in microphone.   Some new Tablet PC models also incorporate an array of microphones for better audio quality.

One final disadvantage is that the instructor would occasionally forget to make gestures on the tablet. Perhaps from old habits, the instructor would occasionally make hand gestures on the screen projection itself. While visible in the classroom, such gestures were obviously not captured in the recording. Using this technology the instructor must make a conscious effort to gesture with the stylus alone.

2.3 Student Survey

An online survey was conducted midway through the CS1 course to gauge student reaction to the Tablet PC.   A total of 16 out of 21 students submitted

responses. The results are shown in figures 5-7. The first question compared Tablet PC delivery to a traditional blackboard:
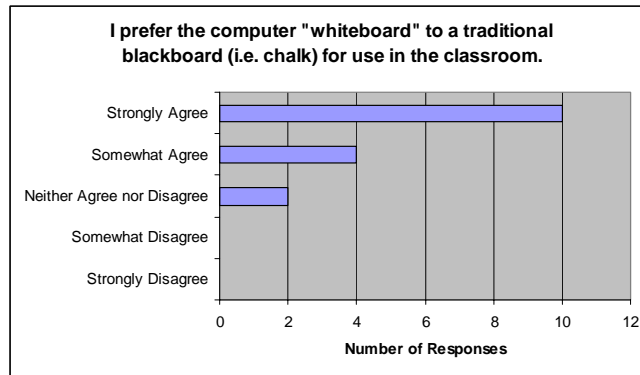

Figure 5. Tablet PC vs. Traditional Blackboard

Students mostly preferred the Tablet PC over a traditional blackboard. Some of the comments to this question were illuminating:

"By far way easier to read, and obviously it is nice to interact with any type of computer during a CS class. Strange really, as my grade would probably be lower and my attention span far less if it was on chalkboard."

"It is simpler for the professor to write, he is never in the view, it is recorded and available."

"I think that this technology should be implemented in place of all blackboards, white boards, and traditional projectors. With the exception of math classes which should still be taught with chalk."

"The whiteboard allows the professor to write programs prior to the class and have them ready to show. This allows class time to be spent on lecture and not writing programs on the board. It allows for efficient time usage."

The next questions asked if the students were viewing the recordings and if not, their primary reason:

Have you viewed any of the lecture video recordings?

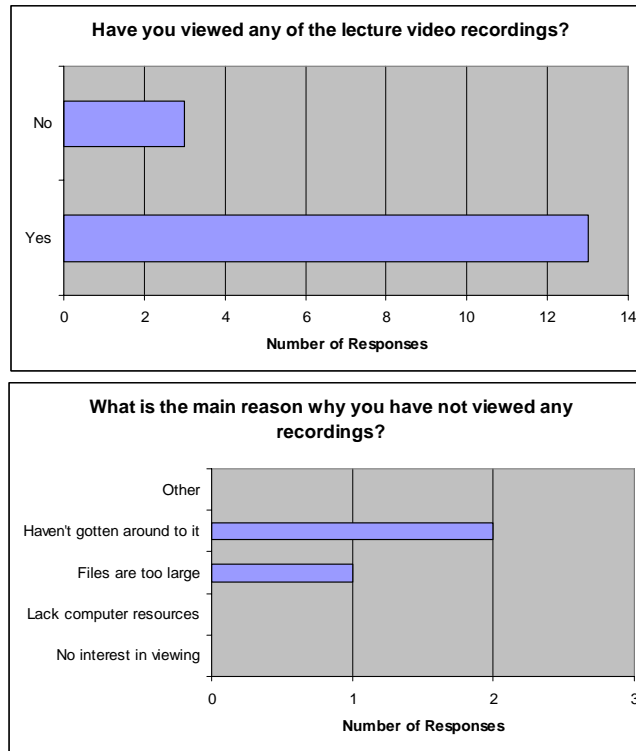**What is the main reason why you have not viewed any recordings?**

Figure 6. Student Responses to Recordings.

Almost all students viewed the recordings (13 out of 16 respondents). Unexpectedly, of the three students that did not view the recordings, only one student did not have sufficient resources to download and view the large files.   The final group of questions asked the students that had viewed the recordings questions about their use and the quality:

Overall, I found the recordings helpful.

I use the recordings to see what was covered if I am unable to come to class.

I use the recordings to review material covered in class a second time.

The video and audio quality is sufficient to understand what was covered in class.
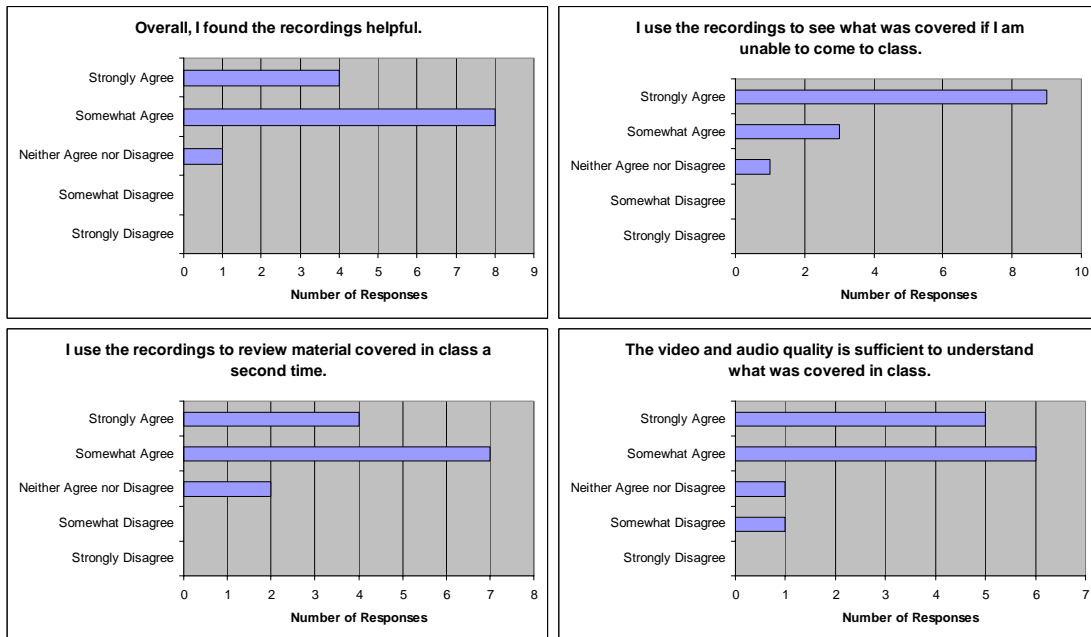

Figure 7. Responses to Students that Viewed Recordings.

A majority of students found the recordings helpful. The most popular use appears to be for finding out what happened if they were unable to attend class. A few responses indicated that students did not come to class specifically because the recordings were available. The recordings were also used to review the material a

second time, although students did not agree as strongly as using the recordings for missing class completely. Finally, the video and audio quality appeared sufficient for most students despite some difficulties in capturing auditory questions from the audience.

Finally, students were given a textbox to enter unrestricted comments regarding the technology. A few selected comments are:

"I like the recorded lectures a lot. I've missed a few classes due to illness but have been able to watch all the lectures I missed via the web."

"Less time is spent erasing the whole board, you can go over the lecture again if you want to."

"Besides the fact that it is just really cool, the fact that you are using a computer and can be there to do things like record your lecture, actually compile code, etc... really lends itself well to a CS course."

"I view the recorded lectures instead of coming to class."

2.4 Tablet PC for Software Engineering

We also used the Tablet PC to conduct a software engineering course. This course was conducted primarily using slides developed in PowerPoint. Both Office XP and 2003 enable the annotation of ink on presentations slides. The instructor used the stylus to highlight items or to coordinate exercises. Figure 8 illustrates a brainstorming exercise, where students are discussing advantages to the IEEE 830 specification.

Figure 8. Annotating PowerPoint lecture.

One area specific to SWE that we found the Tablet PC to be particularly useful was the construction of UML diagrams. When designing UML diagrams there are often new components to insert. This can be difficult to do on a traditional blackboard without a significant amount of erasing and re-drawing. With the aid of UML drawing tools it is very easy to insert new components. Furthermore, pen-based input makes drawing and linking components even easier than using the mouse. We used both Visio and Tablet UML to create UML diagrams interactively in the class. Tablet UML has the advantage of recognizing strokes and turning them into UML components automatically; e.g. for a class diagram, a roughly drawn box will be recognized and turned into a cleanly drawn class object as shown in figure 9.

However, accuracy is not 100% and at times the software would make an unintended interpretation.
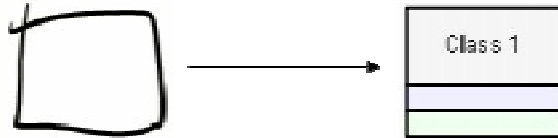

Figure 9. Tablet UML recognizes a hand-drawn box as a class

3. TABLET PC USAGE OUTSIDE THE CLASSROOM

The Tablet PC is also quite handy for faculty use outside of the classroom. When preparing lecture material such as figures and diagrams, we were often able to draw and create these items more quickly with the pen than with a mouse.   Papers and assignments can also be marked up as one would mark up a physical paper. Both Microsoft Word and Adobe Acrobat support ink annotations on a document.   The instructor found this particularly useful when traveling – instead of carrying a large stack of papers, documents were conveniently edited on the Tablet PC while waiting in the airport.
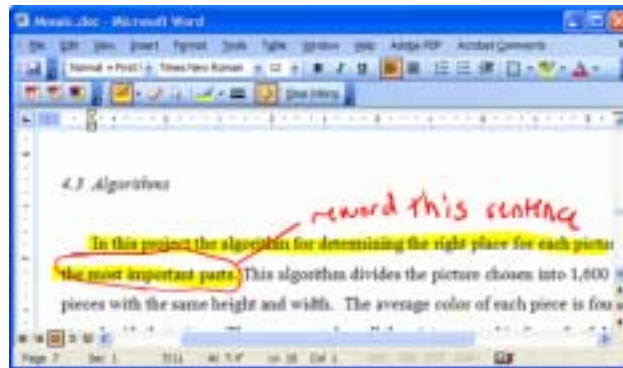

Figure 10. Grading a paper with the Tablet PC.

The Tablet PC has also been quite useful for note-taking at conferences, department meetings, research meetings, and committee meetings. Microsoft's OneNote product has the capability to electronically organize, search, and edit electronic handwritten notes. This has helped reduce the number of cluttered notes normally scattered across the faculty member's desk. A study by Stefanucci found that students preferred notes taken on a Tablet PC compared to notes taken on paper. Some of the factors in the Tablet's favor included the ability to quickly copy and paste diagrams to reflect layered changes to the diagram as made by the instructor on the board, the ability to highlight and flag important concepts, availability of colors and ink, and the ability to add new space to notes instead of cramming material into fixed margins [5].

Finally, the Tablet PC has promising potential for use as a distance education tool. All content can be managed through one tablet device: audio lecture, handwritten material, prepared electronic slides, and live software demonstrations. Several software programs allow such content to be streamed live for use with synchronous distance courses, or archived for asynchronous courses.

4. CONCLUSIONS

This paper has described how the Tablet PC can be used as an effective tool for grading, preparing lectures, and delivering classroom presentations.   It provides a

simple way to integrate live, handwritten material with slides and figures prepared in advance. Lectures can be easily captured for viewing at a later time. Rather than save the lecture as a static document, our work explored methods for capturing lectures into Flash movie files so that audio and gestures could be recorded. Students reported very positive feedback about the approach. In the future we intend to explore uses of the Tablet PC for distance delivery and collaborative applications where all students in a classroom are working on Tablet PC's. Just a few years ago, data projectors were a novelty in the classroom. Today, many classrooms are equipped with fix-mounted data projectors as a standard piece of equipment in the classroom. We believe the Tablet PC may follow a similar path due to the many benefits that may be derived from its use.

5. REFERENCES

[1] Anderson, R., et. al. (2004). Experiences with a Tablet PC Based Lecture Presentation System in Computer Science Courses. In Proceedings of SIGCSE '04, Norfolk, Virginia March 2004. ACM Press.

[2] Clark, C. (January, 2004). Notre Dame Tablet PC Initiative. Retrieved 3/10/2004 from http://www.nd.edu/~learning/tabletpc/

[3] Lowe, P. (March, 2004). Bentley College students evaluate Tablet PCs. Retrieved 3/10/2004 from http://www.hp.com/hpinfo/newsroom/feature_stories/2004/04bentley.html

[4] Microsoft Corp. (November, 2002). Massachusetts Institute of Technology Changes the Face of Education using Tablet PCs. Retrieved 3/10/2004 from http://www.microsoft.com/resources/casestudies/ShowFile.asp?FileResourceID=1196

[5] Microsoft Corp. (April, 2004). Future Professor Puts Note Taking to the Test Retrieved 5/25/2004 from http://www.microsoft.com/Education/StefanucciFeature.aspx

[6] Mock, K. (2003). The Development of a CS0 Course for Distance Delivery. The Journal of Computing Sciences in Colleges, 19 (2), p. 30-38.

[7] Simon, B., et. al. (2004). Preliminary Experiences with a Tablet PC Based System to Support Active Learning in Computer Science Courses. In Proceedings of SIGCSE '04, Norfolk, Virginia March 2004. ACM Press.

[8] Wachsmuth, B. (September, 2003). SHU Tablet PC Project. Retrieved 3/10/2004 from http://www.cs.shu.edu/tabletpc/