ONE STEP BEYOND: LECTURING WITH A TABLET PC

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Abstract

In the Fall 2005 semester, the authors used a Tablet PC during lectures as a replacement for the chalkboard. The Tablet PC allows the instructor to write on the PC screen while facing the students, similar to an overhead projector. The advantage is that the entire presentation can be saved in electronic format and uploaded to the course website, where it is available to both the students and instructor immediately after the session ends. Students and the instructor can focus on concept learning rather than transcription. With wireless capability the instructor would be able to walk around the room while projecting his solutions in real time. This paper reports on two specific case experiences with this tool, including student data on usability and satisfaction.

Introduction

The Tablet PC is the next step in the evolution of laptop computing. Smaller, faster, more powerful technologies and better integrated software capabilities provide the impetus for this step. Equipped with a touch-sensitive screen, users can enter data directly through the use of a stylus (pen) or utilize a traditional keyboard. There are several different types of Tablet PC's, but all allow the use of digital ink to generate new documents or annotate existing documents. Included software allows professors to write and problem solve as they would using traditional pad/pencil using Journal™ or write directly on Word™ or PowerPoint™ slides, save the document or slides including the notations, and provide them to students in electronic form. This combines the ease of digital presentations with the interactivity of the overhead/ chalkboard. For example, professors can work out detailed solutions on the computer screen, project the solutions in real time, and save solutions on the hard drive, all while facing the students. A brief overview of Tablet computing and its development can be seen in Table 1.

The 60's	The 70's	The 80's	The 90's	Today
Ivan Sutherland develops Sketchpad, a pen/Tablet input technology (non-integrated)	No significant 'Tablet' developments but Sonic Pen, a 3D input device becomes available; Pong is created by Atari; Xerox begins work on GUI, and Apple incorporates	The first 'portable' computers by Tandy appear; Apple debuts the book-like Navigator; First pen-based point select system by GRiD an IBM PC compatible PC Tablet	GO Corp. creates 1st sole pen-based OS; MS releases Windows for pen computing; Apple releases Newton (PDA); handwriting recognition improves w/ 'Graffiti'; arguably first convertible Tablet PC appears	Several integrated Tablet 'types' being offered, better handwriting recognition software; better designed and integrated software for Tablet use begin catching on

Table 1. Evolution of Tablet PC Technology [1,2,3].

Tablet PCs can combine the advantages of traditional presentation methods while mitigating the limitations. Applications for the Tablet PC include the ability to enhance lectures and problem solving, chunk and clarify information, illustrate relationships through use of colored inks, and create complex figures and diagrams. Tablet PCs can also easily support active learning, collective brainstorming, reading, commenting, marking-up (providing feedback), and grading of student work.

This paper reports on the experience of two engineering faculty members and how their implementation of Tablet PCs and related pedagogy impacted their engineering classrooms at Penn State.

Literature Review

The Tablet PC is making inroads in the educational arena. A review of the current literature indicates that instructors are capitalizing on their potential for active and student centered learning in the classroom. Tablet PCs also provide unique characteristics that lend themselves to academic environments[4] benefiting both instructors and students. Specific advantages are noted in the area of classroom lecture, presentation, note taking, and the interactive dissemination of information, as well as document mark up, grading, commenting and feedback.

The use of the Tablet PC as a lecture aid provides the best of both teaching worlds. Tablets afford the opportunity to present prepared lectures with well thought-out graphics for examples and the ability to annotate and develop the lecture or presentation in real time just as you might using a blackboard[5]. Tablet PCs are active learning technologies as pen based input capabilities facilitate bi-directional sharing of information, moving students beyond observation of presentations to interacting with the material, the teacher, and each other[6].

The use of "digital ink" for mark-up, grading, commenting, and feedback is becoming increasingly popular across a variety of domains.[7] As course supports and materials move online, challenges become apparent. The traditional methods of marking, grading, writing comments, etc. become more complex. Jennings, McCuller, and Stephan[8] outline the various choices at the instructor's disposal today as well as the unique advantages and disadvantages of various digital inks. Perhaps the most difficult challenge facing instructors is grading assignments that have been electronically submitted[9]. Pen-based mark up using a Tablet PC provides a more natural approach to this issue of grading electronically submitted materials.

Statement of the Problem

While many faculty have taken to using presentation software such as PowerPoint™ in their classrooms, others continue to use overhead projectors and chalkboards to demonstrate solutions and present information. Each of these technologies has limitations.

PowerPoint™ slides must be completely prepared in advance, and pacing is difficult for the instructor, as it is hard to know how long it takes a student to copy down information. It is also easy to slip into the habit of reading the slides to the students, which results in a phenomenon our students refer to as "death by PowerPoint™".

Chalkboards require the instructor to have their back turned to the students for significant periods of time. Student questions may go unanswered and the instructor will be unaware of visual clues normally provided by the students. The professor's body tends to block segments of the board, making it difficult for students to see properly. Students must copy the board verbatim, and errors may occur. Additionally, if the professor talks while writing it is difficult to hear.

Overhead projectors are often misused by including too much information (as when an entire page of text is copied onto a

transparency). Faculty can face the students, but information must still be copied by the students.

Description of the Study

Over the past year, Engineering Instructional Services (EIS) has conducted two informational workshops on the Tablet PC. Several faculty members were interested in trying the technology and EIS worked with the Leonhard Center and Information Technology Services (ITS) to put the associated technology in their hands. What follows are separate case reports in each instructor's voice. Case #1 describes an implementation by a Mechanical Engineering (ME) professor and the use of the Tablet PC in two of his classes. Case #2 explains an implementation and use of the Tablet PC in an Electrical Engineering (EE) course. Each professor was asked to provide a written reflection on his experience, listing the hardware and software used.

An online survey tool with eighteen questions was created to gather data from students related to attitudes and preferences regarding the Tablet PC use, how the Tablet impacted their learning, and how the tool was implemented and used in the classroom. The question format afforded students the ability to indicate or select choices and then explain that choice further. Examples are provided in Figure 1.

Case Report #1 – Mechanical Engineering (ME)

Hardware Used

The Tablet PC used was an older Toshiba Portege running Microsoft Windows XP Tablet Edition. It had a Pentium M 1.6 Ghz processor with 512 MB RAM. The machine had a 40 GB Hard Drive. It also contained Intel WiFi and had Bluetooth capabilities.

Access to a video projector was afforded in the classroom and could be hooked up via simple cable connection to the Tablet PC.

Software Used

Microsoft Journal, Microsoft Word, Microsoft PowerPoint, and Adobe Acrobat were used as Tablet applications. Microsoft Excel and Internet access were leveraged from the podium computer as there was simple access to a keyboard for input when using those applications.

Q1. Please select the statement you **most** agree with
    - (1) It was better when the instructor used the blackboard in class
    - (2) It was better when the instructor used the Tablet PC in class

Q2. Why?
    (user had space to elaborate)

Q. 3 What effect did the instructor's use of the Tablet PC have on your **attention to the lecture materials**?
    - (1) I paid much less attention
    - (2) I paid a little less attention
    - (3) There was no effect
    - (4) I paid a little more attention
    - (5) I paid much more attention

Q.4 Why
    (user had space to elaborate)

Figure 1. Excerpt from Online Survey.

In The Professor's Words

"I saw a Tablet PC for the first time last year when a colleague, Tom Litzinger, brought one to a committee meeting, and used it to take notes. I immediately foresaw a great application for Tablet PCs in the classroom. Fortunately, I was able to borrow a Tablet PC (Toshiba Portege) to use in two courses that I taught in the Fall semester of 2005. The two courses are very different. The first course is required for Mechanical and Nuclear Engineering juniors – ME – 33 Fluid Flow. It was a large class of about 80 students in a big lecture room (135 Willard). The second course is a technical elective for seniors and grad students – ME 405 Indoor Air Quality Engineering. There were only 23 students in this course, and it was in a small room (75 Willard). Both rooms were equipped with video projectors and computers, and both had cables and switches for easy connection to a laptop or Tablet PC. Despite the great differences in students, class size, and level of course, the reaction of the students was nearly the same - they loved the Tablet PC!

"As part of a research project, I used the Tablet PC in every lecture of both courses except for five lectures in each course during which I used the blackboard. This was done to gauge the students' preference for blackboard vs. Tablet PC. The response of the students was overwhelmingly in favor of the Tablet PC. They liked the colors, the clarity of the display, the larger size of the writing, and most importantly the fact that I could stand there facing them instead of facing the blackboard with my back to the students. To make the comparison as equal as possible, I posted my lecture notes from both cases - blackboard and Tablet PC - onto the course website. For the case with the Tablet PC, I simply converted the journal file I created in class to a pdf file and posted it. For the case with the blackboard, I scanned in my hand-written notes into pdf format and posted it. The students preferred the Tablet PC over the blackboard in spite of the fact that in either case the lectures were posted. In other words, the fact that the Tablet PC lectures could be posted on

the website was eliminated as a factor in this study.

"How did I use the Tablet PC for my courses? Before class, I would set up a journal file with a heading that included the day's date, lecture number, etc., along with a few introductory comments - things I would normally write on the blackboard right before class - reminders of homeworks due, refreshing their memories about what we discussed in the previous lecture, etc.

"I would have the Tablet PC on and ready to go when I arrived in class. All I had to do was connect the cable, press the <FUNCTION>-F5 key a few times, and the Tablet PC's display would appear on the classroom screen. I found it very easy to use, especially because Penn State's technology classrooms have a button that enables the instructor to switch sources from the Tablet PC to the room PC in an instant. I found this feature to be extremely useful. I would switch back and forth between the room PC and the Tablet PC several times in a lecture. I used the Tablet PC primarily as a writing Tablet to deliver course notes. I used the room PC to show them images and files on the Internet, run software applications like Excel, etc. I could have done that from the Tablet PC as well, but I found it more convenient to run such applications using the room PC because of its full-size keyboard and mouse. One disadvantage of the Tablet PC is that when you have it in Tablet mode, you do not have access to the keyboard or scroll pad, making it too difficult to run applications like Microsoft Excel in which you need to enter a lot of numbers. The electronic keyboard that comes with the Tablet PC is useless, in my opinion. I would rather convert the Tablet PC back to a laptop and use the real keyboard, than use the electronic keyboard.

"Here is another nice feature that I used a lot: I would import a Microsoft Word file into the Journal file on the Tablet PC. Then, in class, I would open up the Journal file and write with the Tablet PC pen over top of the Word

document. This was especially useful for in-class example problems. The problem statement itself, along with figures and other information, would already be there, imported from a Word file that I had created ahead of time. Then, using the Tablet PC pen, I would work out the solution in the blank space area just below the problem statement. This is perhaps the nicest feature of the Tablet PC, since it saves precious class time - the instructor does not have to draw the diagrams and given information on the blackboard, and the students do not have to write down all this information either. I found that in this fashion, I was able to cover more material. Occasionally in a lecture, I would import a complex picture or drawing (pre-made before class), and place it into the Journal file. This would also save time, since I didn't have to draw the picture from scratch, as one must do with the blackboard."

Case Report #2 – Electrical Engineering (EE)

Hardware Used

The Tablet PC used was a Lenovo/IBM X41T[10] running Microsoft Windows XP Tablet Edition 2005. The machine is equipped with a 1.5 GHz Pentium-M Low-Voltage processor, 1 GB of dynamic RAM, a 60 GB hard disk drive, and a 12.1-inch (300 mm) display with a resolution of 1024 x 768 pixels, and both wired and wireless (802.11abg) LAN. One of its major advantages is that it weighs only 3.5 lbs (1.6 kg), so it is easy to carry around during class.

While the video output of the Tablet PC could be directly connected to a classroom projector with a cable, the instructor chose instead to use a Linksys[11] WPG54G wireless presentation player (WPP). This device allows the Tablet PC's video to be transmitted wirelessly to the classroom video projector, leaving the instructor free to walk anywhere in the classroom while presenting. If connected to the campus network, it also allows the instructor access to the internet while presenting.

Setting up the hardware takes less time than waking up the Tablet PC and starting the desired software application. The instructor usually carries the Tablet PC and the WPP with him to class and connects a video cable between the WPP and the classroom's external video projector input, plugs in the WPP's power cable, and turns on the projector when he arrives in class. The additional step of connecting a LAN cable between the WPP and the campus network is only necessary on days when internet access is needed.

Software Used

The major application that this professor used in class was Microsoft PowerPoint™. Although "a PowerPoint presentation is a good way to put your class to sleep", this professor did not use the application as a method to simply present information that the students sit and passively listen to. Instead, he used it as a replacement for the blackboard, but one that's smart enough to allow him to incorporate graphic images, charts, graphs, and sketches.

All Microsoft Office applications are ink-aware - (refers to the output of the Tablet PC's pen while writing on the surface of the display, and provide the ability to write on top of the display). In *Slide Show* view in PowerPoint, for example, you can write on the display with several different styles of pens, and in any color that you choose. There's also an eraser tool. ("I use that one a lot!") The information that you write is stored on a separate layer in the program's file structure called the *annotation layer*. After the presentation is finished you are given the choice of either saving or discarding your annotations. If you save them you can later go back and selectively add to, erase, or even completely remove them. This is helpful if you want to clarify something that you covered in class. Your changes can be highlighted or written in a different color so that the students notice them when they look at the finished notes for the day.

In addition to the Microsoft Office programs, this instructor used the following Tablet PC software in class:

- Adobe Acrobat 7 (full version; not Adobe Reader) – contains some inking capability
- PDF Annotator – allows you to annotate any pdf-format file and has better inking tools than the Adobe product
- Windows Journal, provided with all Tablet PCs – a basic sketching application that uses a sheet of Tablet paper as a metaphor. You can write on the Tablet paper, add graphic images, and import any file that can be printed
- Microsoft OneNote – uses a 3-ring binder metaphor to help organize your notes

In The Professor's Words

"I used a Tablet PC in the classroom during Fall 2005 semester as a replacement for the traditional blackboard and/or overhead projector. The class was EE 310, Electronics I, a required course in the fundamentals of electronics, taught at Penn State University. This paper details some of my experiences with the technology including the use of wireless video technology for displaying the images from the Tablet PC on a large screen in the classroom."

"EE 310 is a course in the fundamentals of Electronics, and is required of all Electrical Engineering (EE) and Computer Science and Engineering (CSE) students at Penn State. Normally taken in the sophomore year, the course is the second in a series of "core" courses in the EE curriculum. Topics covered are the fundamentals of solid-state devices including diodes, bipolar junction transistors, field-effect transistors, and operational amplifiers. Consisting of three 50-minute lecture periods and one 3-hour lab per week, EE 310 exposes students to material that will enable them to analyze and design both linear and digital electronic circuits."

"The lecture material is graphically intense, requiring the instructor to either sketch complicated figures on the blackboard or to bring overhead transparencies or PowerPoint slides containing the figures to class. In some classrooms the projection screen covers the blackboard, making it challenging to switch seamlessly between the blackboard and the figures. Additionally, the course material is best learned by doing rather than by just being a passive listener, so methods that encourage more classroom participation by the students are highly desirable."

"I used a Tablet PC in class as a tool to address many of these issues. A Tablet PC allows me to prepare graphically intense material ahead of time and to upload the material to the course web site so that students can view the material before coming to class. In fact, I encourage them to print out a copy of the lecture material, which is in a very rough outline form but contains most of the figures and graphs to be used in class, and to bring the printout to class so that they can work along with me."

"During lecture, the video output of the Tablet PC is connected to the input of the classroom video projector, and a large image is projected onto a screen in the front of the classroom. The need for alternating between blackboard and screen is eliminated because all material is presented on-screen. As the lecture proceeds I can refer to the on-screen graphics and use the Tablet pen to highlight items or to solve equations. Students can write on their copy of the notes but are relieved from the need to recreate all of the figures and graphs; thus they can concentrate more on learning the material and less on trying to be stenographers."

While it is possible to do the same thing with an overhead transparency projector and marking pens, the Tablet PC allows the instructor to:

- run software applications (analysis and simulation tools, for example)
- incorporate videos or animation into the presentation
- access content on the Internet
- skip the steps of making transparency copies before class and then erasing markings from them after class
- upload marked-up notes to the course web site after class"

Survey Results

Students in the three courses were asked to complete the online survey on a voluntary basis. Of 163 students, 108 responded (66%). Of the 108 respondents, only one stated that s/he preferred the chalkboard to the Tablet PC.

As previously mentioned, the question format afforded students the ability to indicate or select choices and then explain that choice further. Table 2 provides compiled data for questions 1 and 3 of the survey.

Student feedback regarding how the tool was used in the course and how that use impacted their learning was very positive. Students noted that the use of the Tablet and subsequent projection in class was especially helpful because it allowed the instructor and them to work with complex diagrams that kept their continuity across examples. Many students commented that the use and projection of the Tablet made any seat in the classroom a good seat and that you did not have to sit up front to know and see what was going on or being taught. Lines of sight and visibility were noted as key improvements.

Students also noted it impacted on the feel and tone of the classroom. Quite a few noted that the position of the instructor – facing forward had several effects. First, by facing forward the instructor was easier to hear. The instructor was also more aware of the students in the course – making them feel like the instructor was more invested in the class and themselves. One even commented that despite their class being a large lecture class, it made the sessions seem more warm and personal.

When the students were asked if there were any important classroom activities that were facilitated by the instructor having a Tablet, the feedback showed that the ability to have copy prior to class, the intentional use of color, continuity of examples, and the ability to integrate materials/media were important features. The use of color when utilizing the various inking tools allowed instructors to present complex information in ways were more easily understood by the students. Learners seeing the color coded notes could mark

Question 1 Summary			
Selected	Value	Choice	Total Value
1	1	It was better when the instructor used the blackboard in class	1
107	2	It was better when the instructor used the Tablet PC in class	214
108 Total Responses			
Average Response: 2.0: It was better when the instructor used the Tablet PC in class			
Question 3 Summary			
Selected	Value	Choice	Total Value
2	1	I paid much less attention	2
3	2	I paid a little less attention	6
35	3	There was no effect	105
50	4	I paid a little more attention	200
17	5	I paid much more attention	85
1		Blank Response	
108 Total Responses			
Average Response: 3.8 I paid a little more attention			

Table 2: Survey Summary For Questions 1 and 3.

individual sub-processes that were occurring and make better sense of the complex materials being presented. Complex concepts could be chunked and simplified through the use of color. Comments related to view-ability and visibility were overwhelmingly positive with the use of the Tablet and subsequent projection. Pacing and keeping up with the instructor was also facilitated by the Tablet use.

A result of having the material in electronic copy was that it afforded the students the ability to bring pre-class notes into class. These partial notes helped students attend to the concepts being taught as opposed to feverishly copying diagrams and writing down instructor commentary. Students particularly note the ability to concentrate more on what the instructor was saying making it easier for them to understand and follow content materials.

Students were also asked to compare the instructor's content/delivery style between traditional teaching and using the Tablet. Student feedback noted a change in the pace and flow of a Tablet delivered course vs. a blackboard driven course. Blackboard driven courses were slower paced. Of interest here is that the slower pace was related to the time the instructor had to take to draw an example on the board. Students also noted that more content could be covered in the Tablet based classes because the instructor no longer had to draw and re-draw in class. The result of this was that students noted that more examples could be covered as well as more material in the space of a class period. But perhaps most interesting were the comments that noted the importance of the instructor facing the class and being able to make eye contact with them and that the instructor was no longer talking into the blackboard. One student even noted that using the Tablet made them feel like the instructor was more accessible to the students.

Specific points that student mentioned regarding how the instructors could improve 'delivery' and use of the Tablet in class to benefit their learning included suggestions to

make the cursor more visible and therefore seen more easily, pacing scrolling when presenting and/or referring to content, and to use the handwriting recognition of the Tablets to better advantage.

Of course, the instructors had comments and feedback regarding implementing the Tablet in their classrooms. Each of the professors, who as investigators participated in this case study, have specific insights and impressions, given their use of the Tablet PC. The ME professor notes,

"Overall, both I and the students in both of my courses were thrilled to have had use of a Tablet PC. I must say that now that I have become used to it, *I would never want to teach a class again without a Tablet PC*! I highly recommend it for all instructors. One piece of advice to instructors - make sure you have the Tablet PC pen with you when you go to class. On at least one occasion, I brought the Tablet PC, but forgot the pen. I had to quickly run back to my office to get the pen. Without the pen, the Tablet PC is useless in class, especially for the purposes with which I use it."

The EE professor provides the following perspective:

"Anyone who has taught engineering classes knows how difficult it is to get engineering students to participate in class. The Tablet PC has facilitated classroom discussions for the following reasons:

- The instructor is facing the students, making eye contact
- Everyone in the room can clearly see the "blackboard", even students sitting in the back of the classroom
- The students are working on problems with the instructor instead of just sitting back and listening
- The students aren't preoccupied with taking notes
- The instructor can walk around the room and ask questions directly to specific

students, making it easier for them to answer (or, harder for them to avoid answering)! Students learn by doing, rather than by observing."

This professor was careful to point out that these comments, of course, are coming from the instructors' perspective, but many of the instructors' comments are supported by the student data.

Limitations of the Study

A limitation of the current investigation is that the data are self reported. With that said, student feedback to this point is overwhelmingly positive regarding the way the Tablet PC's were used in these three initial courses as can be seen in the detailed qualitative information that was collected. Suggestions were also solicited from the students that will guide further implementation and use of the Tablets in the classrooms.

Recommendations for Future Research

Based on this preliminary research, several areas of investigation have been identified related to: visibility, the instructor facing front, the use of ink, and the use of notes. The issue of visibility was consistently mentioned. One line of inquiry here might be to investigate the impact of visibility on student interactivity in the class. Of particular interest would be to investigate the impact of visibility and how it might allow the 'back of the class' to become more actively involved. Factors related to the instructor facing front have been identified; further research should be conducted in this area. The use of ink would be interesting to explore in the classroom as a way to support and scaffold learning – especially complex problem solving. The use and availability of instructor generated student notes opens several lines of investigation. Students consistently mentioned the advantage of being able to bring partial notes to class. Research into how this impacts student learning should be explored. Students also noted that having partial notes allowed

them to attend more to what was being said. It would also be interesting to consider the impact of note creation on the instructor. This too, should be investigated. This investigation has confirmed our belief that the implementation of Tablet PCs and related pedagogy into the engineering classroom at Penn State has the potential to impact both students and faculty in a positive way. Further scrutiny of the faculty and student feedback will provide continued direction for our research in this area.

Perhaps things are best summed up in the words of one of the instructors as advice from one faculty member to another "I feel that this technology is helping me to become a better teacher. I've been able to get the class more involved in the course material, and I'm able to spend more time on concepts rather than on the mechanics of writing and transcribing figures".

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