

Evaluation of Tablet PCs for engineering content development and instruction

Jeff Frolik and J. Brooks Zurn

University of Vermont

Introduction

Over the past decade, there has been a great deal of activity across disciplines attempting to incorporate computing into the classroom environment. The now near ubiquitous nature of multimedia enhanced classrooms is indicative of the perceived benefits of this technology. In terms of instruction, these enhanced classrooms have enabled faculty to replace or augment chalk/whiteboard lectures with a variety of new pedagogy. At the extreme end of the spectrum are wireless or tetherless classrooms where students each have their own mobile computing device. Using these devices (laptop or PDA), students can in real-time view and interact with lecture material that incorporates multimedia, web-based content and experiments. For example, under this scenario, an instructor could embed web-based simulations in his/her lecture that can be accessed to further illustrate the points¹. After students have experimented with these simulations, the instructor can then query the students as to what was discovered and how these discoveries relate to the subject of the lecture. However, results to date indicate that instructors must commit significant time and effort to make effective use of inclass computer technology^{2,3}. Studies have also shown an additional shortcoming of using laptops, namely that students can not effectively use keyboards for note-taking³. This is especially true for engineering courses where the material is often mathematically and graphically intensive. On the surface, pen-based entry enabled by Windows XP based Tablet PCs promises to address the shortcomings noted above. However, given their recent introduction (Q1 2003), there have been no studies to show their effectiveness in an academic environment. This paper discusses the author's experience in content development and instruction using the Tablet PC. The evolution of the pedagogy and lessons learned over an academic year are presented along with student feedback. In addition, the co-author provides a student's perspective in using the device both in and out of class.

The Tablet PC for Course Content Development

For content development, the main advantage of the pen-based technology is that notes, equations and graphics can be hand-written and captured in an electronic form. These electronic course notes can be easily edited to incorporate interactive multimedia content such as Internet links, simulation routines, audio, images and video or simply to update/correct the material. Clearly such content can be embedded in, for example, Microsoft Word or Power Point files. However due to the equation and graphic intensive nature of the engineering discipline, such content development becomes tedious due to the constraints of keyboard/mouse-based equation editors and drawing utilities.

The author developed his base course notes using Microsoft Journal (which is included with Windows XP Tablet PC Edition). This package allows one to enter written material using a variety of pen styles and colors as shown in Fig. 1. In addition, one can embed images that can subsequently be annotated as shown in Fig. 2.

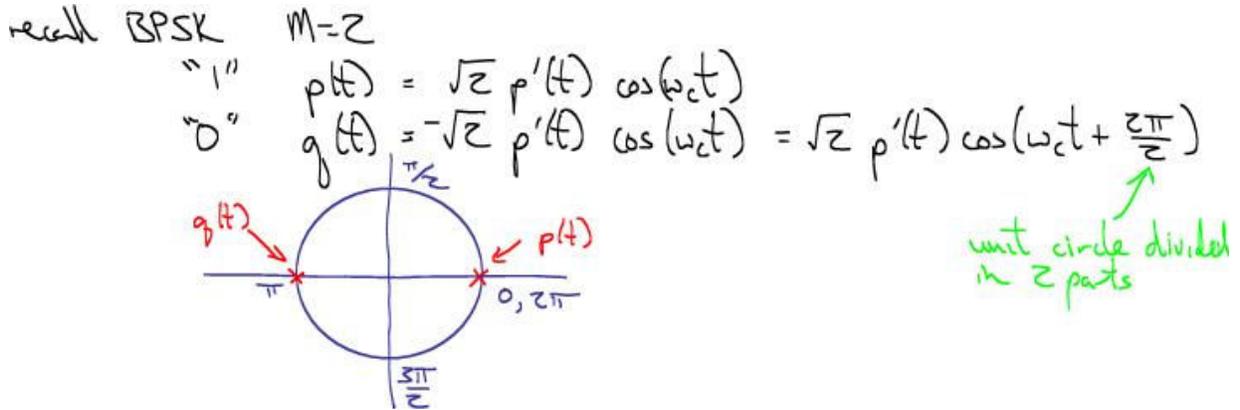


Figure 1. Example of notes developed in Microsoft Journal

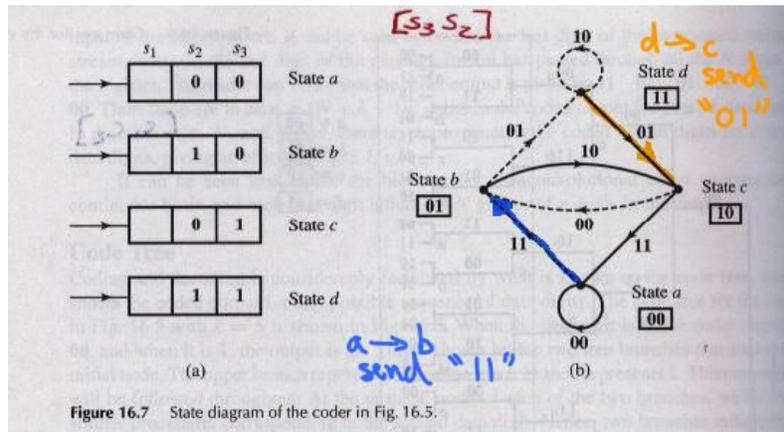


Figure 2. Example of imported image (scan from text) annotated in Microsoft Journal

The use of Journal improves on the author's previous paper-based method for incorporating images in notes. Now content from a variety of sources (e.g., scans, Internet and simulations) become part of the electronic document in their original format (vs. printed and taped on to paper notes). The author's initial intention was that he would use the developed notes as presentation material for his lectures and incorporate break points in the lecture to discuss the material (more on this later). As such, these notes were planned to be complete in their content.

The Tablet PC as an Instructional Tool

It is evident to the attendees of this conference that just as students have individual learning styles that faculty also have individual teaching styles that they are comfortable with. The author is most comfortable when actively moving in the class and hence had only used multimedia content for specific images or simulations and the remainder of the time used the chalk/whiteboard. However, since a new tool was being investigated, the author polled his

students as to the advantages and disadvantages of the various instruction methods they had been exposed to. Without exception students specifically compared chalk/white board lectures and PowerPoint type lecturing styles (noticeably absent was active learning/project based courses). A summary of their input is given in Table 1 below.

TABLE 1: Survey of student impression with lecturing styles

Method	Advantages	Disadvantages
Chalk/whiteboard	<ul style="list-style-type: none"> ▪ Learn by seeing the progression of material. ▪ Flexible format so that elaboration is easily incorporated. ▪ Student is engaged by writing and thus staying focused. 	<ul style="list-style-type: none"> ▪ Spend most the time writing. ▪ Difficult to listen, write and understand all at the same time if instructor moves too fast.
Presentation	<ul style="list-style-type: none"> ▪ More material can be covered. ▪ Material better organized and can clearly emphasize important concepts. ▪ Visually appealing. ▪ Possible to have notes in advance. 	<ul style="list-style-type: none"> ▪ Student is not actively participating by taking notes and thus can zone out. ▪ Good for top level but not for detail (e.g., steps involved in solving a problem). ▪ Not as flexible and too gimmicky.

Several of the students clearly pointed out that they absolutely preferred the chalkboard technique to a multimedia presentation. Albeit this was a small sampling of students (11), it was interesting to find that none noted that embedded electronic content as an advantage of the presentation format.

In short, the author's plan to simply present previously developed notes did not only differ from his personal preference but did not match the preference of his students. As such, the instructional technique was modified as follows. A base set of notes (along the lines of what was seen in Figs. 1 and 2) are prepared in advance and made available to students through the course's WebCT site. Since many students do not have PCs running Windows XP (which incorporates a Journal reader functionality), the notes are posted in both Journal and PDF format. These base set of notes are complete in terms of content, as opposed to seminotes^{3 4}, but also do include probing questions which are addressed in class. Instead of displaying/discussing the base notes in class, new notes are created using Journal which are projected using a multimedia setup. Since the students have the base set of notes prior to class, the tone of the in-class notes are more explanatory/elaborative in nature. Among the advantages of rewriting the notes are the same as those noted by the students in regards to chalk/whiteboard lecturing. Namely: rewriting the material enables one to show the progression of equations, figures, etc., allows for flexibility in what is presented, engages the faculty and the students, and finally ensures a proper pace for the presenting the material.

Since the Tablet-based lecturing is being performed on a fully functional PC platform, simulations, websites and images can be readily integrated during the lecture (as opposed to switching multimedia equipment). In short, the Tablet enables the instructor to seamlessly marry the best features of chalkboard and multimedia lecturing techniques. One shortcoming of the methodology from the instructor's perspective is the limited field of view that the Tablet provides (as opposed to two full chalk/whiteboards). As such, under scenarios where a figure or equation was referred to repeatedly, it was written on the board for reference. However, a definite advantage of the Tablet is that everything written during the lecture (and previous lectures) is available for future reference. One simply needs to scroll through the notes to revisit this material (versus rewriting something erased earlier).

Course Content Development: Revisited

As noted, two sets of electronic notes are developed; the base set and the in-class notes. From the in-class notes, the instructor has a record of what questions were asked during the lecture and the written clarifications provided. This record can subsequently be used to update the base set of notes for the next course offering. Obviously updating notes does require some effort. However, since both documents are electronic, updating can be as simple as cut and paste.

While embedding images in Journal is relatively straight forward, the program does not support embedding other types of content (e.g., URL links). However, Adobe Acrobat does support this functionality and thus can be used to create an interactive set of base notes for the student. This type of dynamic course content may prove quite effective for distance learning environments. Furthermore, PDF documents can be annotated either using keyboard/mouse entry or Tablet PC stylus. As such, students can download the notes to be covered prior to the lecture and to annotate directly on these notes during the lecture or while studying. The end result is that students can have a customized, paperless course-pack.

The Tablet PC as a Learning Tool: A Student's Perspective

From the student's perspective, a Tablet PC has many advantages over traditional note-taking and presentation methods. One major benefit of the Tablet PC is its portability – with a Tablet PC it is possible to carry notes for a great number of classes without requiring extra weight or space. This also makes it easier for the student to study in almost any environment (e.g., in the library or on the bus), simply by taking their computer. Another benefit is the search functionality of Windows Journal, which can easily find specific words in the handwritten contents of one note or many notes at once. This makes it unnecessary to convert handwriting to text, and saves a great deal of time when studying specific topics. When the lecture notes are made available to the student in Journal format, these can be searched for terms and used as a reference both during and after the duration of the course, enhancing their long-term usefulness to the student.

The co-author primarily used the program Journal over two semesters for note-taking. As noted, Journal is ideally suited for the diagram and symbol intensive nature of typical engineering classes because input can be drawn as shown without requiring special keystrokes or software (unlike an ordinary laptop computer). Taking class notes can be faster and more effective when using Journal – repeated phrases or equations can be copied and pasted, words and drawings can be moved around, and different colored writing or highlighting can distinguish key points and make diagrams clearer. Due to the similarity between the Journal interface and a traditional sheet of notepaper, there is no loss in note-taking speed, even on the first day of use. This ease of use is in stark contrast with other note-taking devices such as handhelds using Palm OS and Pocket PC, where proficiency is only possible after significant practice. Overall, attending a lecture presented using a Tablet PC improved the co-author's experience both in and out of the classroom.

Conclusion and Future Work

The response of the students to the instructional methodology discussed herein has been overwhelmingly favorable to date. Students are definitely appreciative of two main aspects: (1)

having notes ahead of time and (2) seeing the progression of the material as the notes are being written in class. Certainly these two aspects can be accomplished without the Tablet PC, but ease of creating and updating notes and having a single lecturing platform for all types of content have justified its use to the author.

The author is presently investigating using Tablet PCs in a laboratory course as an interactive lab book for student results. One can envision using the Tablet PC to provide the procedure, run simulations, control test equipment, capture test data and provide a means of capturing handwritten comments. In addition, we will investigate using Tablets for students to document their activities in a senior design course. Rather than submitting formal reports on a regular basis, the Tablet would provide a paperless trail of the design process and enable the instructor to view progress at regular intervals. The perceived advantage of the pen-based entry is that students will be able to concentrate on ideas whether they are in the form of text, equations or sketches rather than spending effort to present cleaned-up documentation (this will be left for more formal reports and presentations).

In conclusion, the Tablet PC is a relatively new technology and thus a broad set of experiences are not yet available. However, based on the experiences of the authors, the Tablet PC has shown to provide true pedagogical benefits from both faculty and student perspectives. As a final point we provide a question for the reader to consider. Since many universities require students to purchase a computer, could the Tablet PC bring about (finally) a true return in learning for the investment in classroom infrastructure made by the universities?

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BIOGRAPHIES

JEFF FROLIK received the B.S.E.E. degree from the University of South Alabama, Mobile in 1986, the M.S.E.E. degree from the University of Southern California, Los Angeles in 1988 and the Ph.D. degree in Electrical Engineering Systems from The University of Michigan, Ann Arbor in 1995. He is currently an Assistant Professor in the Electrical and Computer Engineering Department at the University of Vermont (UVM). He is the recipient of the ASEE Southeastern Section New Teacher Award in 2002 (while at Tennessee Technological University).

J. BROOKS ZURN received the B.S.E.E. degree from the University of Vermont, Burlington in 2003. She is employed by MED Associates, Inc. (Georgia, VT) and was a NSF Fellowship Recipient for attendance at the IEEE International Summer School on Biocomplexity from System to Gene held at Dartmouth College, July 2003. She is currently pursuing a M.S.E.E. at UVM.