

INSTRUCTIONAL USES OF TABLET PC'S IN STEM LEARNING ENVIRONMENTS

Cheryl Willis, Susan Miertschin, and Driss Benhaddou

College of Technology, University of Houston, Houston, TX 77204

Email: clwillis@uh.edu, smiertsch@uh.edu, dbenhaddou@uh.edu

Abstract

Tablet PCs are increasingly used as teaching and learning tools to create and enhance technology enabled learning environments. In 2004, Willis and Miertschin identified tasks that information workers in a learning environment (i.e., faculty and students) perform to get their work done—note-taking, creating and giving presentations, document markup, teaming and collaboration, and information management. They further proposed that because of their form factor and capability for pen input and control, tablet PCs are an appropriate tool to enhance learning environments for undergraduate STEM disciplines. Tablet PCs emerged in 2003 as an integration of several technologies including pen input and control together with handwriting recognition, audio input and control together with voice recognition, plus integrated mobile technologies such as Intel® Centrino® mobile technology. The resulting single footprint hardware package has spawned software development and inspired educational experimentation, especially in areas where keyboard input is not ideal, such as symbol-rich abstract mathematical representation of physical and social phenomena. Since that time, the authors have personally experimented with and promoted to their colleagues applications of the Tablet PC to improve instruction and learning in STEM areas.

This paper relates tablet PC functionality to the tasks required of faculty and students as information workers. A review of recent literature is provided and the authors document their varied personal experiences using tablet PCs. In particular, one author has experimented with and documented his use of the tablet PC to enhance online instruction in engineering technology, finding that the tablet PC offers advantages in terms of complex formula development and in significantly reducing class preparation time. The other authors document multiple experiences experimenting with a classroom set of tablet PCs to provide students experience with this emerging technology. Survey data about related student experiences is presented.

Introduction

With Microsoft's first introduction of the Windows XP Tablet PC Edition operating system (WinXP TPC OS) in 2003, several hardware manufacturers introduced their flavor of the tablet PC (TPC).¹ Since that beginning, another version of the WinXP TPC OS has been released and many new models of TPCs have been introduced. Also in the interval, faculty in STEM disciplines have accepted the challenge of using the new technology in their classrooms both as an instructional support tool for the instructor and as a learning tool for the students.

What is a Tablet PC?

A Tablet PC is a PC that has been modified at both the hardware and software levels to differentiate it from other PCs and to make it more functional for mobile computing. Some TPCs are “slates” without a keyboard attached; others are “convertibles,” designed to look like the traditional laptop but with the capability of converting to a slate configuration via a mechanical joint that connects the screen to the keyboard/processor base. The viewable display in either type can quickly be oriented to portrait or landscape orientation without having to reboot the system.

TPCs have special screens which use an active digitizer to enable users to write directly on a protective transparent cover over the screen in order to input information as handwriting or drawing and also to control their computer.² As shown in the illustration (Figure 1) provided by Wacom Technology, the pen sensor components of the TPC are the sensor board, an LCD display, a cover with protective glass, and an electronic pen. The sensor board uses the electronic pen (stylus) to send a signal to the display indicating where the pen is on the screen.

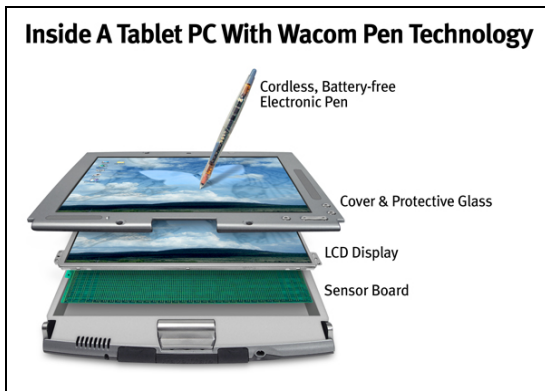


Figure 1: Pen sensor components of tablet PC – source: <http://www.wacom.com>

The screen size on 2004 models ranges from 10.4” to 14.1” with the median being 12.1”. The weight ranges from 2.6 lb to 8.4 lb, depending to a great extent on whether the keyboard is attached or not. The battery life ranged from 3 hours to 9 hours.³ Most current models use Intel Centrino technology with Pentium M processors and the screen sizes and battery lives follow advances in those technologies. Most TPCs have built-in wireless network connectivity which adds to their mobility—you can stay connected as you stroll through the halls, allowing those spur of the moment hallway meetings to be formally recorded. The compact form factor gives rise to a more comfortable way to compute—reclining, lying down, walking around, standing, sitting with the TPC in your lap, or sitting with it on the desk in front of you. Furthermore, there is no compromise with respect to computing power as compared to a traditional laptop computer, and the form factor provides computing that is easy to carry and as simple to use, in some contexts, as a paper and pen.

In terms of software modification, the operating system includes handwriting recognition and speech recognition engines that allow handwritten or spoken statements to be converted to text. The digitized handwriting can be converted to typeface text through the handwriting recognition engine that is part of the WinXP TPC OS, or it can remain as handwritten text.

The TPC latest edition of the XP Operating System provides a pop-up input panel that can switch among a virtual onscreen keyboard, a block character input panel, or a handwriting input panel.

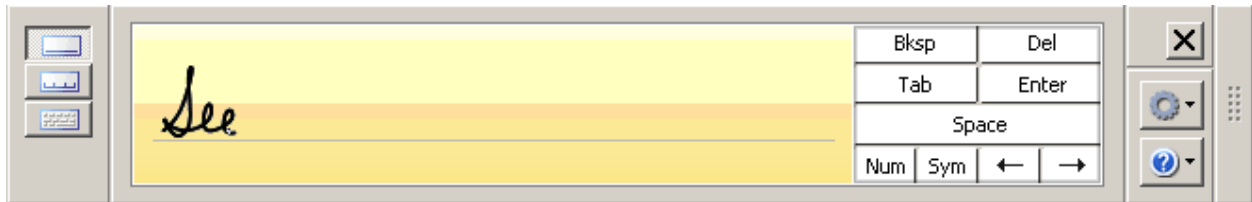


Figure 2: Tablet PC Input Panel

The digital ink technology built into the TPC, and capitalized on by applications developed for the TPC, provides more than just a one-dimensional view of text and graphics on a page, however. The phrase—ink as ink—alludes to the fact that digitized handwriting has as much meaning as text in typeface.⁴ Both standard text and handwritten text are valid sources of information for the users of the TPC in learning environments.

Uses of Tablet PCS in STEM Learning Environments

The authors investigated tasks that information-literate students and faculty need to do in order to get work done in a learning environment⁵. Tasks identified include note-taking; creating and giving presentations; document mark-up; teaming and collaboration; and information management. In this paper, we use these tasks as a framework to discuss current literature on the use of TPC's in STEM disciplines and our own experience with using TPCs in the classroom.

Note-Taking

One task that faculty and students must complete is note-taking, in seemingly endless meetings or classes, respectively. The paper notepad, however, is “the most impenetrable silo of important information in corporate America.”⁶ The use of TPCs in meetings or the classroom eliminates the distracting click, click, click generated by those using keyboards. In addition, the screen of a TPC does not present a physical barrier between the note taker and the others in the meeting or class, since the screen, which is the writing surface, lies flat instead of perpendicular and in front of the note-taker. The aesthetics of having a pad-like computer sitting on the desk in front of you or in your lap while you use a pen to write is much less obtrusive than other options.⁷

Microsoft® provides a number of software innovations for TPCs that are relevant to the task of note-taking. Microsoft® Windows Journal is an application designed specifically for note taking on a TPC, and it is available free as part of WinXP TPC OS⁸. The digital ink functionality plus the form factor of the TPC provides a natural note-taking experience with the bonus of being able to store the information-rich virtual paper (v-paper) electronically. The software allows the user to capture notes freeform on an endless sheet of virtual paper (v-paper), with different ink colors, highlighting tools, and other features. Mistakes (a.k.a., inkos) can be erased using the Wacom pen's eraser technology which mimics a pencil top mounted eraser. The style of the v-paper background for the notes page can be made to look like ruled notebook paper, sheet music, or graph paper, among others, to facilitate note taking in various academic areas. Even more specialization can be achieved by creating v-paper templates. Figure 3 below shows a sample Journal note on graph ruled v-paper, with icons for various note-taking tools visible on the

toolbar. The variety of writing utensils along with v-paper is suggested as a motivational advantage of the TPC. It is theorized that the note-taking options help keep our digitally-native students engaged and thus they take more notes.⁹

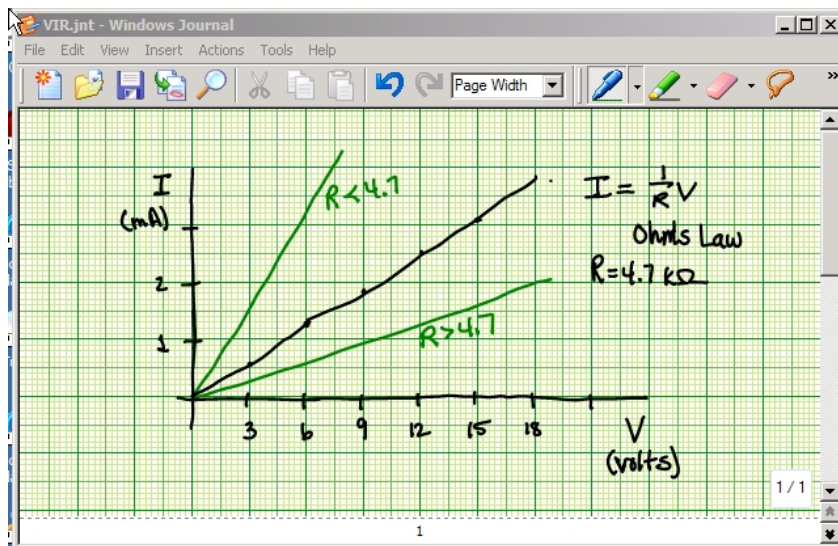


Figure 3: Microsoft® Windows Journal page from graph paper template

Digital ink is searchable in Microsoft® Journal and other TPC applications that make use of the handwriting recognition engine. Journal's search function can find specific character strings across a specific note or across Journal files saved in a folder. Thus, if a student wants to find any instances of when a specific topic, say "click event," was mentioned in a semester's worth of Journal notes, the term could be searched for within a folder where the student saved notes for the semester.

Creating and Giving Presentations

Presentations are a key means of disseminating information—particularly in learning environments. The TPC can facilitate the process of participating in presentations—creating, giving, and using. With respect to creating presentations in presentation software, the digital ink functionality of the TPC in the form of cursive handwriting, block lettering, or a combination of both, is acceptable as input to any Office 2003 application. Unlike in Microsoft® Journal, handwriting is automatically converted to typeface text in Office 2003 applications (unless a feature called Ink Annotations is turned on). In addition, the built-in microphone of a TPC or a plug-in microphone can be used together with the voice recognition engine to input data into an Office 2003 application.

In facilitating students' learning from lecture presentations, a faculty member has a number of options with a TPC. She may simply present a lecture using a TPC instead of a laptop or desktop and becomes a digital blackboard. Microsoft® PowerPoint software can display the slides as the instructor creates lecture annotations in real time. As shown in Figure 4 below, ink annotations can be added during the slide show view of a PowerPoint presentation, with the option to save the digital ink annotations to the original or another file at the end of the presentation. Further benefits accrue when the instructor makes the updated slides available to the students. If original

slide files are made available to students prior to the presentation, then students with TPCs could write their own lecture notes directly on the slides.¹⁰

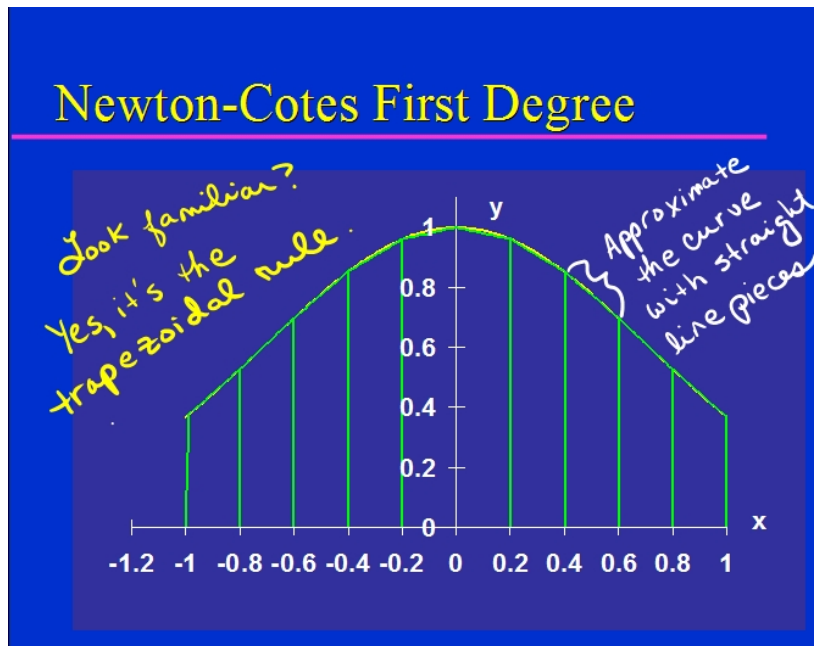


Figure 4: Handwritten ink annotation on a Microsoft® PowerPoint slide

It has been theorized that the presenter more fully engages the audience by writing directly on the slide text to add emphasis.¹¹ The capability of adding written comments or answers to questions from students has been observed by one of the authors to increase student engagement in the discussion of the content.

Even a blank blackboard can be simulated with a TPC by saving several blank slides in a PowerPoint file. When run in class in slide show view, the instructor makes notes directly on the blank slides using the TPC rather than the blackboard. To insure that the instructor never runs out of room on the simulated whiteboard, an alternative to PowerPoint is Windows Journal with its continuous writing surface. These digital whiteboard notes can be saved and shared with students.

Documents created with applications installed on the Tablet PC can be “printed” out to the Windows Journal format (.jnt), so that the original document that can be opened and written on in the Microsoft® Journal application. Using this approach, an instructor can prepare a set of lecture notes, a lecture outline, or a set of lecture questions for the students and “print” these out from PowerPoint, Excel, or Word to .jnt format. Students with TPCs can then open the .jnt version and annotate the document as the lecture proceeds. One of the authors has made test solutions available to the students electronically in this way. See Figure 5 for an excerpt from the exam solutions. Note the way Microsoft® Journal handles multiple-page documents with the page bar seen at the bottom of the picture. Even students without a TPC can use Journal notes such as the exam solutions illustrated. A viewer application is available for download for use in such situations (<http://www.microsoft.com/windowsxp/tabletpc/default.msp>). Journal notes can

also be exported as a Web Archive file (mht format) for viewing in Internet Explorer or in tif format for viewing in other browsers.

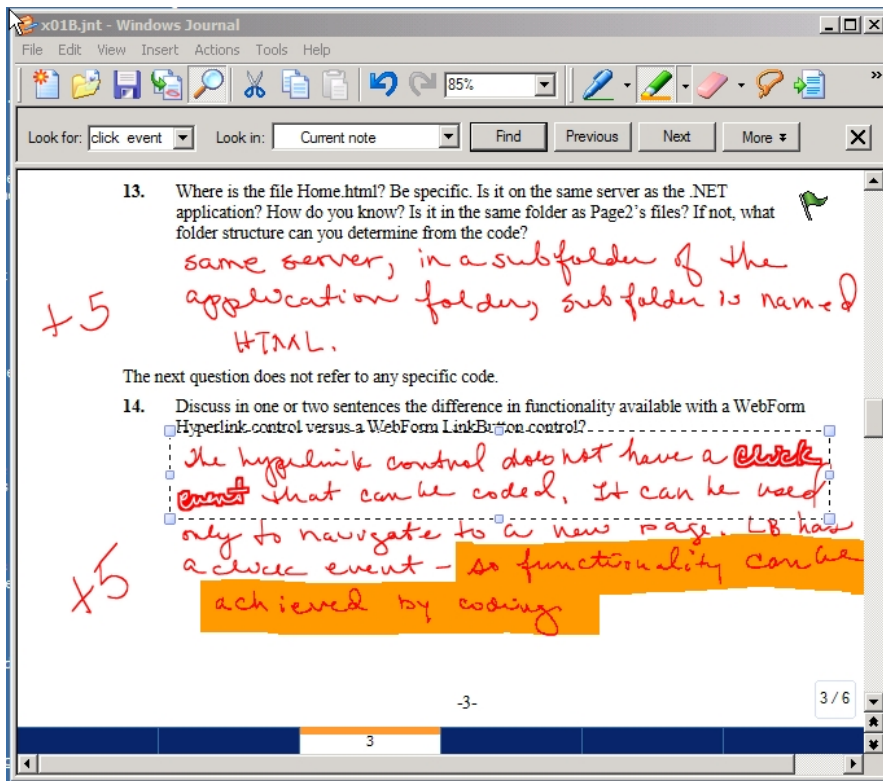


Figure 5: Microsoft Word document printed to Windows Journal

The Page Bar feature is unique to Journal. The Page Bar contains an icon for navigating to each page (or slide) in the document. The use of the Journal provides the presenter with a greater range of pens and highlighters and the possibility of having more than one presentation open at the same time.

An additional enhancement to using the TPC to deliver a presentation is to record the presentation while it is being delivered. Camtasia Studio offers a low-cost means of synchronized recording of audio and the TPC screen image of a lecture regardless of what software application is being used for the presentation.¹²

Interactive Presentation Systems

Several systems have been developed to integrate enhanced learning environment functionality. Classroom Presenter, developed by the University of Washington, allows the instructor to broadcast his slides to all students.¹³ The instructor, as well as the students, can annotate these slides. Students can also provide aggregated feedback on the instructor's slides. Livenotes is a cooperative note taking system for use with student groups.¹⁴ Lecture slides are imported into the system's whiteboard feature for students to write on. The whiteboard gives students in each group the ability to add notes to the imported slides that are visible by the other members of the group.

Delivering Online Lectures

Another approach to presentation of mathematically oriented content in online settings was used during fall 2005 by one of the authors delivering a junior level optical circuits course in a synchronous online mode using Horizon Wimba software. The author used two presentation modes. He presented conceptual material with supporting PowerPoint slides, talking through the material. For the development of concepts through mathematical analysis, he shared the Microsoft® Journal application from his TPC with students who could then see the application remotely on their home PC. There the author used the TPC and its digital ink to write and solve equations extemporaneously and in context with conceptual material.

The author conducted a survey of student opinion with respect to how digital ink and the TPC presentation helped them follow the lecture and understand mathematical material. The survey revealed that a majority (58.3%) of students agreed or strongly agreed that digital ink helped them be more engaged during the lecture while the remainder of students were neutral (no student disagreed). In addition, a majority of students agreed that digital ink helped them understand more fully the development of a mathematical solution to a problem. There were some students (about 16%) who did not perceive any value added from digital ink.

Document Markup

The digital ink technology of the TPC allows faculty to mark up electronic documents of many formats by inserting ink annotations directly onto the digital document. Documents from applications can be made ready for mark up using a TPC by importing them within Journal or by printing them to Journal format from the originating application. According to Lindsey, the document markup capabilities of the TPC also have implications for use in distance education: “The ability to write directly on the file using the tablet PC saves me the time and hassle of having to print the assignment, grade it, scan it, save the scanned copy and then e-mail it back to the student” [7, p. 18, p. 20].¹⁵ One of the authors has provided ink feedback to students using this process. An excerpt from a student file with markup is shown in Figure 6.

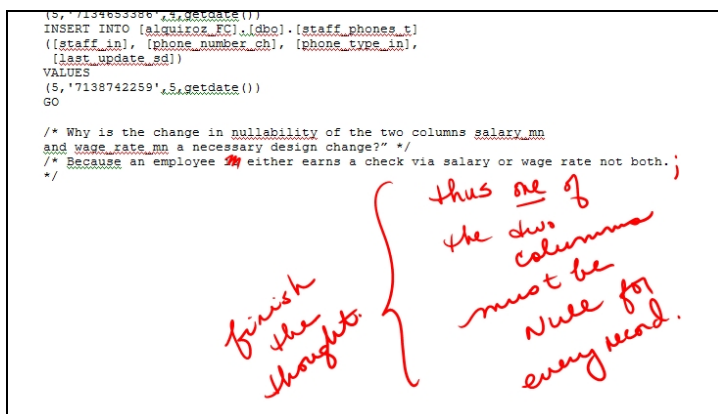


Figure 6: Student work with mark up

Students as well as faculty members need to mark up documents. Reading of online documents becomes less of a chore for students with the TPC. Articles or handouts that need to be read for

a class assignment can be printed through the Journal Note Writer virtual printer, giving the students a softcopy of the document that can be underlined, highlighted, and saved for later search and reference.

Teaming and Collaboration

Collaborating on documents or projects with others in the same room is often more difficult than collaborating on documents or projects with others across the globe—especially if there's no wired or wireless infrastructure available. With Colligo Workgroup Edition software, there's no need for central access points, servers, or Internet connections.¹⁶ The software can create collaborative peer-to-peer networks instantly with other nearby Colligo users by using the ad hoc mode of any wireless-capable machine—Tablet PC, laptop, desktop, or Pocket PC. Figure 7 shows the Colligo users who are currently online and the type of computing device they are using to connect.

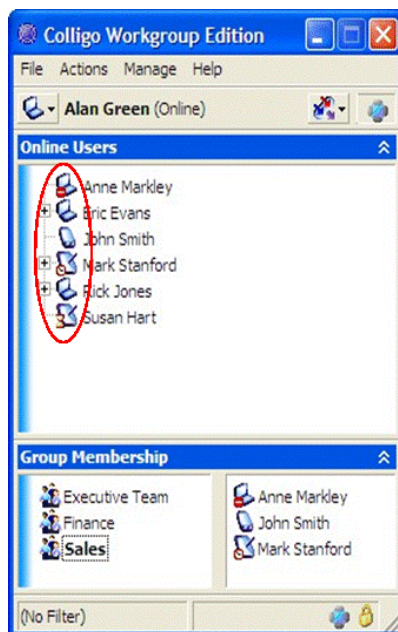


Figure 7: Colligo Online Users and Group Membership Panes.

Source: <http://www.colligo.com/index.asp>

The digital ink capability of TPC's makes the collaborative features of Colligo easier to use—chat, whiteboard, and instant messaging—and with the NetMeeting feature in Colligo, applications can be shared across the instant network. Colligo also allows file transfers and printer sharing.

Teams can set up their own network within a network for private team exchanges and communication. Thus, Colligo and the TPC's can be used to simulate global virtual collaboration within the confines of a classroom. For instance, as shown at the bottom of Figure 7, three groups have been established and three members of the Sales group are online.

Information Management

Faculty and students, as well as other knowledge workers, spend a lot of their time looking for information—on their desks, in file folders, or on hard drives. The real key to improved knowledge worker productivity is to be able to access all relevant information in a timely manner. Perhaps the solution to the explosion of virtual documents in education is based on the three-ring binder with an index tab for each course. There are products on the market that are developed specifically for information management of electronic documents based on the three-ring binder experience and that capitalize on TPC functionality. One such product is GoBinder, a product primarily for students developed and marketed by Agilix Labs.¹⁷

An advantage of GoBinder over Windows Journal is the user interface, which captures the workflow needed for e-binder document creation, storage, retrieval, and dissemination in one place (see Figure 8). Agilix has formed a partnership with Blackboard, an online instructional delivery system, to integrate the functionality of GoBinder and Blackboard.

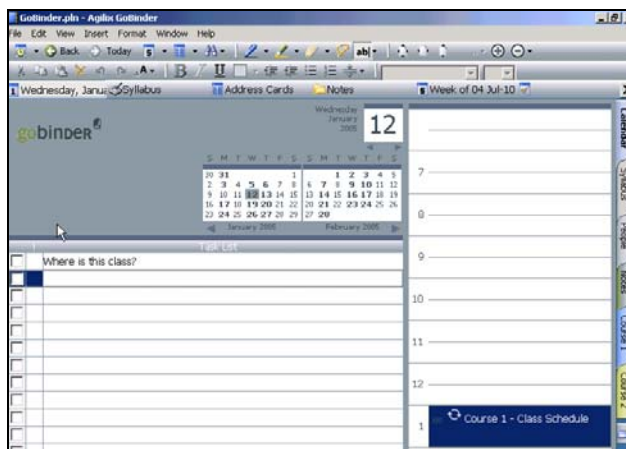


Figure 8: Agilix Lab's GoBinder user interface

Conclusion

This paper looked at the functions of the information worker within the context of the learning environment. We provided background on the strengths that TPC's and its supporting technologies bring to bear on the learning experience, particularly, note-taking, creating and giving presentations, document markup, teaming and collaboration, and information management. The TPC is also a very practical tool to get students engaged in online education especially with material having to deal mathematical formulations.

Acknowledgments

The authors would like to acknowledge the University of Houston's Faculty Development Initiative Program for its support which partially funded the projects referenced in this work.

References

1. Microsoft Corporation. (2002). New tools to use with your PC. Electronic file, Retrieved January 31, 2006, Last Updated (<http://www.microsoft.com/windowsxp/tabletpc/evaluation/overviews/pctools.mspx>)
2. Wacom Technology. (2004). Tablet PC, Electronic file, Retrieved January 31, 2006, Last Updated <http://www.wacom.com/tabletpc/index.cfm>
3. Shaw, T. (2004) Tablet PCs: Making Technology Available and Transparent. *MultiMedia & Internet @ Schools*, May/June 2004, p. 36-7.
4. Ross, Suzanne (2002). Inventing the Tablet PC. Electronic file, Retrieved January 31, 2006, Last Updated <http://research.microsoft.com/features/tablet.asp>
5. Willis, C. & Miertschin, S. Tablet pc's as instructional tools or the pen is mightier than the 'board! *Proceedings of SIGITE'04*, October 28–30, 2004, Salt Lake City, Utah, USA.
6. Regenold, S. (2003). Tablet PCs: your new best friend? Presentations: Technology and Techniques for Effective Communication. February 2003. http://www.presentations.com/presentations/technology/article_display.jsp?vnu_content_id=1871531
7. McCloskey, P. (2002). Tablet PCs Stake Out Higher Education. *Syllabus*. December 12, 2002. <http://www.syllabus.com/article.asp?id=6985>
8. Microsoft Corporation. (2004). Windows XP Tablet PC Edition. Electronic file, Retrieved January 31, 2006, Last Updated (<http://www.microsoft.com/windowsxp/tabletpc/default.mspx>)
9. Barton, C. and Collura, K. (2003). Catalyst for Change. *T.H.E. Journal* 31(4) (November 2003) p. 39-41.
10. Villano, M. (2003). Is the Tablet PC the future of college computing? *University Business*, June 2003. <http://www.universitybusiness.com/page.cfm?p=289>
11. Regenold, S. (2003). Tablet PCs: your new best friend? Presentations: Technology and Techniques for Effective Communication. February 2003. http://www.presentations.com/presentations/technology/article_display.jsp?vnu_content_id=1871531
12. Wassgren, C. and Krousgrill, C. (2003). Pen-based PCs for the classroom, Electronic file, Retrieved August 19, 2003, Last Updated http://widget.ecn.purdue.edu/~wassgren/2003_04_03_TLTWorkshop/
13. Anderson, R., et al. (2004). Experiences with a Tablet PC Based Lecture Presentation System in Computer Science Courses. *Proceedings of SIGCSE*, March 2004, Norfolk, Virginia.
14. Kam, M., et al. (2005). Livenotes: A system for cooperative and augmented note taking in lectures. *Proceedings of CHI 2005*, April 2-7, 2005, Portland, OR, USA. 531-540.
15. Lindsey, S.D. (2003). On-demand lectures create an effective distributed education experience. *T.H.E. Journal*, (November 2003), p. 16, 18, and 20.
16. Colligo Networks. (2004). Colligo solutions. Electronic file, Retrieved July 3, 2004, Last Updated <http://www.colligo.com/Products/enterprisesolutions/colligosolutions.asp>
17. Agilix Labs. (2004). GoBinder Features. Electronic file, Retrieved January 31, 2006, Last Updated <http://www.gobinder.com/features.aspx>

CHERYL L. WILLIS

Dr. Willis is an Associate Professor of Information Systems Technology at the University of Houston. Her teaching focus is primarily on applications development and database management. Her research interests include curriculum revision processes; service learning in information technology programs, and the use of emerging technologies in undergraduate teaching.

SUSAN L. MIERTSCHIN

Professor Miertschin is an Associate Professor teaching in the Information Systems Technology program. Her teaching interests are in the development of information systems applications and the complementary nature of back-end developer and front-end developer skill sets. Her research is in the impact of instructional technology on student learning.

DRISS BENHADDOU

Dr. Benhaddou is an Assistant Professor at the Engineering Technology Department, University of Houston. His areas of expertise include optical networking, switching system design, routing protocols in optical networks, embedded systems, and network security.