AC 2007-2111: TABLET PC APPLICATIONS IN A LARGE ENGINEERING PROGRAM

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Tablet PC Applications in a Large Engineering Program

Abstract

A Tablet PC computing initiative was announced by Virginia Tech in summer 2006. Use of Tablet PC-based instruction was implemented in a freshman engineering course with about 1200 students in fall 2006. Examples of instructional activities included electronic note taking, use of inking features to review homework solutions and completing skeleton PowerPoint slides designed to increase the engagement level of students in a large classroom, and setting up online collaboration sessions to do group design project and problem solving activities. In addition, the Tablets helped students maintain an electronic log of their individual and group efforts in completing a 6-week long sustainable energy design project. A summary of assessment data from in-class clicker-based questions and end of semester course exit survey is presented to discuss the effectiveness of Tablet based instruction. Students liked electronic note taking features and quickly became proficient at setting up collaborative sessions using Tablet PC for design and problem solving activities and thought the Tablet PC was a good tool for that purpose.

1. Introduction

The College of Engineering (COE) at Virginia Tech announced a new Tablet PC computing initiative in summer 2006 for incoming freshmen. This initiative made it mandatory for all engineering freshmen (~1200 each year) to own a Tablet PC starting fall 2006 for use in engineering instruction. With this decision, the COE became the largest and first public college of engineering to require the Tablet PCs for the engineering freshmen. The college only recommended the specifications of the Tablet and students bought their machines from a number of manufacturers. Figure 1 shows the response to an exit survey question (~220 respondents) showing ownership of Tablets by brand. It may be mentioned that the Dell computers in this figure were laptops owned by students who were repeating the course. In 1984, the COE was the first public institution in the U.S. to require its entering engineering freshmen to own a personal computer. In 2002, the college moved to a laptop requirement and many of its academic buildings were outfitted to offer wireless communication capabilities[1].

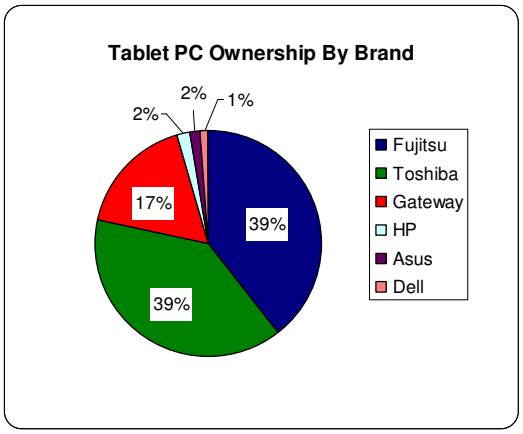

Figure 1: Tablet PC Ownership by Engineering Freshmen at a Large Engineering Program. *Note: Dell computers represent laptops.*

This paper describes integration of Tablet PCs into a required first semester freshman year engineering course called EngE 1024, "Engineering Exploration." Assessment results from in-class clicker-based responses and online course exit surveys are presented to assess the effectiveness of Tablet PC-based instruction. Problems encountered and plans for future enhancements are also briefly discussed. A summary table showing Tablet PC related instruction activities in various other academic programs is also presented.

2. EngE 1024, Engineering Exploration – Background

Engineering freshmen at COE are required to pass two freshman engineering courses during their 1-year long freshman engineering (also called General Engineering (GE)) program. The first course is called EngE 1024, “Engineering Exploration” Over the past seven years, the first-year courses in the GE program have evolved from somewhat standard problem solving (including statics, electrical engineering, material balance concepts), graphics, and programming courses to a format that emphasizes early design and realization, collaborative learning, and highly interactive classroom environments. In 2004, the syllabus of EngE1024 was updated to include general problem solving, engineering ethics, visualization of 3-D objects and also visualization of information, early design (including realization), graphing and simple analysis of graphs, and introduction to object-oriented programming (OOP) approaches for problem solving. Further, significant revisions to the course in light of a new Department-Level Reform (DLR) project from the NSF and a new course delivery format were piloted in spring 2005 with ~210 students[2], and full implementation of these revisions were successfully executed for the entire freshman engineering class (~1200) in fall 2005[3]. EngE 1024 is a 2-credit course and all engineering freshmen are required to pass the course with a grade of C- or better. Traditionally, this course was taught by EngE faculty using two 50-min lessons per week. The new delivery format includes one 50-minute lesson, taught by a faculty in a 150-180 seat classroom, followed by one 90-minute workshop, taught by graduate teaching assistants (i.e., workshop instructors), in a 32-seat classroom each week. The principal reasons for initiating this major change were to: i) allow additional time for students to become engaged in more hands-on activities during the workshop period, ii) create teaching opportunities for graduate students, iii) give students the opportunity to present and to become aware of contemporary engineering issues, and iv) collect/analyze data for conducting engineering education research as part of the DLR project activities. The course has now been successfully offered in this new format for five semesters (i.e., spring 05, fall 05, spring 06, fall 06, and spring 2007). In fact, other freshman engineering courses in the GE program are now following the same delivery format. Before presenting Tablet-based instruction strategies, a summary table giving summary of prior/ongoing Tablet related instructional activities is presented in next section.

3. Review of Tablet PC-Based Instruction Activities

A workshop on the Impact of Pen-based technology on Education (WIPTE) was organized in April 2006 at Purdue University. Table 1 gives a summary of various Tablet-based instruction activities at a number of schools/programs and is an enhanced version of the tables provided in the edited volume of the papers presented at April 2006 workshop[4].

Table 1: Tablet PC Based Instruction Activities[4]

Primary Author	Name of School or Research Firm	Program of Study	Number of Students in Study	Single (S) or Multi (M) Course Study	Major Tablet Software or Activity	Some Findings Regarding Student in the Study
Anderson	University of Washington	CS	44	M	Classroom Presenter	increased student engagement and real-time feedback from instructor
Berque	DePauw University	CS	81	M	DyKnow	DyKnow well received by students and faculty
Carryer	Stanford University	ME	170	S	screencasting lectures	most students felt interaction of lectures increased
Dixon	DePauw University	Economics	30	M	DyKnow Vision	DyKnow may help some learning disabled students; students recognize that Dyknow can help in learning; students acknowledge quality and ease of use of DyKnow
Exter	Indiana University	Education	24	S	DyKnow	students seemed to like using DyKnow in class but not out of class; teacher ed students were positive about using DyKnow
Graetz	Winona State University	Statistics	29	S	Word, Journal, OneNote	students chose to use Word more than Journal and OneNote; over time students used more digital ink in homework.
Greenwood	The Queen's University Belfast	Education, CS, Business	237	M	in-class interaction	students agreed that technologies in lecture was a positive experience; majority said possibility of having work displayed increased motivation; a majority felt tablets enhanced problem-solving
Hubbard	University of Richmond	Math	10	S	DyKnow	students need to be persuaded of replay features
Itoh	University of Canterbury	Japanese	23	M	DyKnow Vision	students were positive about experience; quality of homework assignments and feedback improved
James	University of Central Arkansas	Psychology, Health Ed., Kinesiology	47	M	DyKnow Vision	DyKnow use had no impact on retention and final grades
Knoop	University of Washington	Geology	43	S	GeoPad	Students had overwhelming positive experiences
Koile	MIT	CS	15	S	Classroom Learning Partner	Students' grades improved; instructors could adjust material based on feedback from students; student satistisfaction was very high
Manone	Northern Arizona University	Geology	167	M	NetSupport School	Students grasped concepts more quickly
Mutchler	Rose-Hulman Institute of Technology	CS	25	S	DyKnow	All students liked DyKnow; most felt tablet is better for DyKnow use; students had mixed responses on tablet versus laptop requirements
Payton	Vermont Academy	secondary school instruction (K-12)	25	M	GoBinder	most students felt GoBinder easy to use; a minority indicated that GoBinder improved their grades; a mjaority indicated that GoBinder improved notetaking and organization
Scharff	Pace University	Information Systems, Writing, Film	21	M	NetMeeting	all students preferred direct inking for feedback on essays; most students thought tablets were useful for peer review

Scott	Morgan State University	EE	166	M	OneNote	seems to be an positive impact on overall performance for tablet PCs and note-taking software users
Sloan	Rockman Et Al	Math (K-12)	25	S	DyKnow Vision	students with learning disabilities showed reater learning gains; notetaking and study skills improved
Sorcinelli	University of Massachusetts Amherst	Business Information Systems	68	S	ConferenceXP	integration in web portal, tablet PC functionalities and ConferenceXP helped increase overall technology skills of students; students reported moderate increase in team building skills and significant gains in online research skills
Thede	DePauw	CS	17	M	DyKnow Vision	students preferred DyKnow be used for future CS courses; mixed results for keyboard versus pen for DyKnow Vision notetaking
Williams	Rose-Hulman Institute of Technology	Tech. Comm.	286	S	DyKnow	in-class only access to tablets may influence student attitudes about tablets

It is obvious that a number of educators are exploring potential use of pen-based technology on education across various academic programs. The application at Virginia Tech, however, is the largest such application.

4. Tablet PC Application Strategies

A number of hands-on training activities, including presentations by Tablet PC experts were organized in the beginning and during the fall 2006 semester to provide Tablet-related training to faculty and workshop instructors. Altogether, 5 faculty, 14 graduate students (referred to as workshop instructors) and 8 undergraduate students were involved in EngE1024 instruction in fall 2006. The lead and the 3rd author coordinated various activities of the course. Various instructional features of Microsoft OneNote, a Tablet PC friendly software, were explored to integrate the Tablet PC capabilities to enhance the effectiveness of instruction. The following sections provide details:

4.1 Use of Digital Ink: In order to engage students during the lecture portion of the course, we initiated the use of skeleton PowerPoint slides, which were slides in which key pieces of content were intentionally left out. Students could download the slides before the lecture. Some faculty elected to use the skeleton version during lecture, inking in key words or pictures as they talked. Other faculty used a full version of the slides (in which there was no omitted content); in the full version, material that had been left out of the students' version was highlighted by a change in color. Examples of content that students had to fill in included: *Key words or phrases; Definitions; Lists of procedures or examples; Diagrams illustrating key concepts or terms; and Completion of flowcharts.*

We observed that some students elected to download the slides into OneNote while others used the slides in PowerPoint. The intent was for students to ink notes directly onto their copy of the slides, either in PowerPoint or OneNote. During one lecture, it was noted that students opted to record notes in different formats: inking in OneNote, inking in PowerPoint, typing notes into PowerPoint (either on the slides or as comments), typing notes using a word processing program, or using pencil and paper. Some students opted not to take any notes at all.

4.2 Homework Solutions and Review: Students were asked to do their homework using OneNote starting the 2nd week of the semester. Students were provided with two documents that contained detailed instructions on use of OneNote software. Students wrote the homework solutions in OneNote and turned in hardcopies. This allowed students to have a copy of their submitted work at all times. Students used a combination of typing and inking to complete assignments. In general, faculty reviewed the official solutions in the lecture with the students after they turned in their hardcopies and before they received their graded hardcopies. In the lecture, students opened their electronic copies of their solutions on OneNote. The faculty had an official version of the solution on OneNote. While going over the solution, faculty could ink the OneNote file to highlight key parts of the solution. At the same time, students could compare their solutions to the official solution and make their own annotations on their OneNote files. The use of OneNote for homework allowed students to maintain copies of the solutions for studying purposes. Some students voiced issues with using OneNote to record their solutions; deficiencies included an inability to see all work of a lengthy solution at one time, occasional loss of work due to saving errors, printing problems (primarily with inconvenient page breaks, a problem for which a solution was found), and a learning curve associated with learning to ink, erase, insert spacing, etc. in OneNote. During the 5th week, an in-class clicker survey yielded mixed response (see below) from ~100 students in one of the authors' lecture session about use of OneNote for homework solution.

Question: Based on your experience so far use of OneNote for homework problems has been:

a. Effective for homework review (3%); b. Cumbersome for writing the solution (41%); c. Easy to use for writing solution (2%); d. Options a and b (29%);

e. Options a and c (9%); f. No comments (13%)

During the 10th week of the semester, another clicker question was asked to clarify some questions instructors had about use of OneNote for homework. The clicker question and responses (from ~100 students) are as below:

Question: When doing homework problems using OneNote:

A. I first solve problems on paper and then transfer solutions to OneNote (18%)

B. I directly solve problems using OneNote (49%)

C. In the beginning, I did as in (A) above and now I'm doing as in (B) above (4%)

D. I'm still using a combination of (A) and (B) above (14%)

E. No comment (7%)

4.3 OneNote documents: Two documents regarding the use of OneNote were developed by the authors and were distributed electronically to students in the course. Both student and faculty requests and feedback were vital to the development of these two documents. The first document outlined step-by-step procedures to instruct students in how to set up and utilize the relevant features of Microsoft OneNote. The document went on further to show students how they could organize their notes for their engineering class into the natural hierarchy of sections and folders that OneNote provides. Setting up different folders and sections allowed the students to have a section for their notes from lecture and a section for their notes from the workshop and they could create different folders to keep notes for their other classes including chemistry, calculus, etc. The last portion of this document described in detail with screen captures of every step how the students could use OneNote to establish a shared session. When students use a

shared session they all work on their own individual computer to modify a common document. Every ink stroke made in the shared document on one student's machine shows up on each of the other student's machines if they are all connected to the same shared session. Shared sessions facilitated group collaboration throughout the semester and made sure all students working together had an exact and complete copy of the group's work.

The second OneNote document supplied to the students described ad hoc wireless networks and outlined how students can create ad hoc wireless networks between their Tablet PCs. The ad hoc networks were all created using the built-in features of Windows XP to allow students to create shared sessions between their Tablet PCs even when they were out of range of a wireless LAN. This was particularly useful for students while they were meeting in groups to work on the semester project because most of them are freshmen living in the residence halls and currently the campus wireless network does not have access points in range of most residence halls. This document also introduced various OneNote stationeries which allowed students to do a variety of things ranging from graphing data using a grid to organizing notes from group meetings. The last portion of the document gave detailss about the Microsoft Education Pack for Windows XP Tablet PC Edition. One of the students in the class provided the faculty with the information about the Microsoft Education Pack including its virtual printer driver to digitally send any document to OneNote in the same format as if it were printed on a sheet of paper. This was particularly useful for the students to be able to send the posted course notes to OneNote so that they could use all of the capabilities of OneNote while taking notes in the lectures and workshops.

4.4 Collaborative Problem Solving In Workshop: As discussed earlier, the EngE1024 course delivery format included one 50-min lecture followed by a 90-min workshop each week. Altogether 15 lectures and 14 workshops were held. In order to emphasize various aspects of problem solving, students were assigned to solve a problem during most of the workshops. Students were instructed to use Microsoft OneNote to record their solution to the problems. They typically worked individually on the problems for 5-10 minutes and then entered into a shared session with a few of the students around them to discuss their individual approaches to the problem and to come to a consensus group solution to the problem. Figure 1 shows a schematic of the collaborative problem solving process that was adopted and figure 2 shows a classroom with students doing group and individual work.

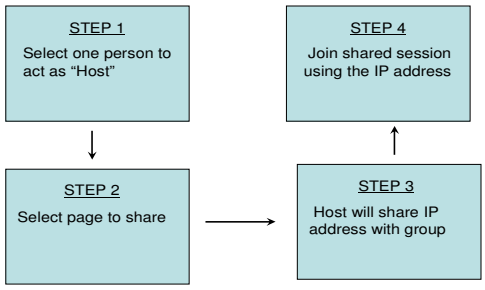

Figure 1: Collaborative Session in EngE1024 workshop using OneNote

Figure 2: Individual and Group Problem Solving Work

While the students worked in groups their workshop instructors gave them some tips about how to collaborate and identify their individual solutions such as dividing the shared paper on OneNote into different sections or using a different color ink for each person. An example problem given to the students is shown below.

Show that the volume of a pool noodle with a regular polygonal cross section is given by:

$$V = \frac{a^2 nL}{4\tan\left(\frac{360}{2n}\right)}$$

Where: V is the volume of the pool noodle in cm^3, a is the side length of the polygon in cm, n is the number of sides of the polygon, L is the length of the pool noodle in cm.

4.5 Design Project Work: As part of EngE1024, students are assigned a 6-week long design project. In fall 2006, students were assigned to design and construct a "Promotional Invention" that promoted awareness of a renewable energy source. The choice of design topic supported the goal of the DLR/NSF project discussed earlier. Each team was assigned one of four renewable energy topics (namely, *hydropower, solar, wind, and biomass)* by their workshop instructor. They were instructed to assume that the audience was the general public, who may have limited knowledge of renewable energy sources. A companion paper at this conference provides details on implementation of this design project[5]. Tablet PCs were used in various facets of the semester design project. Students were taught how to use some of the available stationery to record notes during each of their meetings. This stationery provided a good general template to record who was present at each of the meetings, where the meeting was held, and what was covered at each meeting. At the end of the template the students were given a space to select a time and location for the next group meeting. Students were instructed to use digital ink to have each member of the team present at the meeting sign the meeting notes to indicate that all agreed it was a complete record of the transactions of the team. This was a first attempt in the course to replace a traditional logbook, used in prior semesters' design projects, with an electronic record of the students' work. By making all changes to the log in a shared OneNote session the students were able to ensure that every member of the group had an up to date copy of the team log which eliminates the traditional problem of the student in charge of keeping the logbook losing it or not updating it as the rest of the group expected.

The students presented preliminary prototypes of their design to the class. At this in-workshop showcase, the students were instructed to have some of the members of their team stay with their prototype to explain their design while the other members of their team went around the room and learned about the other groups' work and left constructive feedback for each team. With each student having a Tablet PC, the workshop instructors in some sections decided to replace traditional feedback forms with a page in OneNote (see Figure 3).

Figure 3: Tablet Use for Receiving Feedback on Prototypes

Using the Tablet PCs added the benefit of maintaining an electronic record that is cleaner and easier to maintain than collecting several small sheets of paper. Laptop technology has often limited the ability to quickly communicate an idea using both graphics and text as is often done by engineers in the field, but using the Tablet PCs for feedback allowed students to both write down ideas and include a sketch of any suggestions as appropriate.

While the students met in their groups, many of the groups made use of the ad hoc networking capabilities they had been taught and utilized OneNote in the development of their design projects. The students were asked to discuss in their final project reports the role of Tablet PCs in the design project. The use of Tablet PCs received mixed reviews. Some students thought the Tablets were very useful while others disagreed. A more complete review of student feedback regarding Tablet PC use is included in section 5.0.

4.6 Flowchart Correction: Flowcharts are discussed in EngE1024 to develop algorithmic skills. The Tablet PCs were used in a unique way while the students were learning how to use flowcharts to outline a program. A poorly made flowchart was projected onto a screen and the students were instructed to copy the flowchart. Students were then asked to identify errors in the flowchart and correct them to make a complete and accurate flowchart. Students used Microsoft OneNote on several occasions to draw flowcharts of the programs they were assigned. In some workshop sections, workshop leaders invited students to share the flowcharts they had generated with the class by using a OneNote shared session.

5. Tablet PC Assessment data

As part of an ongoing NSF/DLR project, several formative and summative assessment tools have been implemented in EngE1024. Examples include: use of in-class clickers; student background, learning styles and exit surveys; pre- and post-tests; and focus groups. Following sections present Tablet application related results.

5.1 Exit Survey Summary: Students were requested to complete an exit survey on a volunteer basis at the end of fall 2006 and the survey had a number of Tablet PC related questions. About 220 students responded and a summary of response in respect of each question is given below.

Question: Did you use the Tablet PC in this course?

	Frequency	Percent	Cumulative Percent
No	15	6.9	6.9
Yes	201	93.1	100.0
Total	216	100.0	

It can be seen a small number of repeat students didn't use a Tablet and had a laptop.

Question: Did your skills of using the Tablet PC help you in any manner in other courses?

		Frequency	Percent	Valid Percent	Cumulative Percent
Data Valid	No	128	59.3	63.7	63.7
	Yes	73	33.8	36.3	100.0
	Total	201	93.1	100.0	
Data Missing		15	6.9		
Total		216	100.0		

It can be seen that about 36% of students thought the Tablet PC skills they learned in EngE1024 were helpful in other courses. Students typically take differential calculus, linear algebra, chemistry, English, and one elective class along with EngE1024 in fall semester. As far as the authors know, use of the Tablet PCs wasn't emphasized in any other course with the exception of a special section of Chemistry.

Question: As you know, this is the first year that engineering freshmen were required to purchase a Tablet PC. What in-lecture or in-workshop activities did you think the Tablet PC was useful for? (This was a free response question, the most popular categories of answers are reported below)

	# Reporting	% Responding	Comments
Note taking	73	37.2	Most of the students used their Tablet PCs to take notes in one way or another whether through inking PowerPoint slides, importing the slides to OneNote, or typing information into the PowerPoint files
Sharing/ group work in shared session	53	27.0	The Tablet PCs were used for shared sessions in the workshop almost every week during the problem solving sessions. Most of the students also used shared sessions when meeting with their design project teams outside of the class.
Problem Solving	16	8.2	See above
Homework	12	6.1	This may be a lower than representative number because the homework was not done in class so many students may not have considered this a valid response to this question
Sketching	11	5.6	Sketching was done in class and also for various portions of the group projects and homework.
Reduced paper usage/ No hard copy needed	4	2.0	The ability to use digital ink and to save all notes digitally in one place rather than having multiple paper pages of notes appealed to the students
Flowcharting	3	1.5	The Tablet PCs were used as an aid to teaching flowcharts

Question: If [your Tablet PC Skills helped you in your other courses] please provide some examples of how using the Tablet PC helped you in your other courses (This was a free response question, the most popular categories of answers are reported below)

	# Reporting	% Responding	Comments
Note taking	65	82.3	The ability to import any document into OneNote or Windows Journal was used by many students not only in their engineering classes but also in chemistry, calculus, and other courses for note taking.
Organization	11	13.9	Several students liked the ability of OneNote to organize their notes like keeping a digital binder with all of their notes in one place
Drawing	5	6.3	Some students found the inking capability of their Tablet PCs useful in classes like chemistry to provide an appropriate drawing to complement their handwritten notes. Some of the students in this class also enrolled in a special section of chemistry this semester which emphasized the use of Tablet PCs in the classroom.
Equations	5	6.3	The ability to use a pen and write down an equation in math classes was put to use by several students. Taking notes using a laptop is often difficult if equations are involved because it can be time consuming to enter equations using a keyboard, but being able to write with the stylus reduced this burden on the student.
Homework	3	3.8	A few students reported using the Tablet PCs to complete their homework for other classes
Reduced paper usage	3	3.8	The ability to use digital ink and to save all notes digitally in one place rather than having multiple paper pages of notes appealed to the students

Question: The most frustrating aspect of the use of the Tablet PC in this course was: (This was a free response question; the most popular categories of answers are reported below)

	# Reporting	% Responding	Comments
OneNote	93	47.9	Some students gave specific reasons here while others simply said OneNote itself. The software is obviously not perfect and there are some things Microsoft will probably fix in any future versions of OneNote including correcting auto-formatting problems
Requirement that homework must be done in OneNote	46	23.7	For a variety of reasons many students would have rather had the choice to do their homework with pencil and paper.
The stylus	17	8.8	Stylus technology varied from manufacturer to manufacturer. Some students liked the models that incorporated an eraser capability at the non-writing end of the stylus. The stylus did not allow for much precision and often made it difficult to make fine strokes. The stylus must be calibrated often as many of the Tablet PCs have difficulty in properly placing ink or pointers on the screen in response to the movement of the stylus.
Neatness	9	4.6	Many students found it very difficult to write or draw neatly when using a stylus when compared with traditional pencil and paper.
Cost	5	2.6	Some students felt that the additional cost of the Tablet PCs over traditional laptops was not worth it.

Question: The most interesting aspect of the use of the Tablet PC in this course was (This was a free response question; the most popular categories of answers are reported below)

	# Reporting	% Responding	Comments
Having a stylus to writing/draw on the screen	86	46.7	Many students thought the best feature of the Tablet PC was the ability to write or draw digitally like they could with a normal pen
Shared sessions	28	15.2	Students liked entering into shared sessions to collaborate with their peers
Turning the screen	11	6.0	Some students simply liked the ability of the Tablet PCs screen to rotate

5.2 In-class Clicker Based Feedback: The authors made every attempt to receive feedback from students regarding effectiveness of Tablets in instruction. During week 9 of the semester, the authors asked a series of clicker based questions in this regard. The questions, first two adapted from[6], and responses from ~100 students are given below:

> *Question: I learn best when the instructor uses a Tablet PC to write directly on a PP slide or other electronic file type to illustrate the lecture material.*
> *A. Strongly agree (10%); B. Agree (23%); Neutral (39%); Disagree (12%); Strongly disagree (12%)*
>
> *Question: I'm more engaged in the lecture when the instructor uses a Tablet PC pen to highlight or add material to a projected visual aid.*
> *A. Strongly agree (11%); B. Agree (35%); Neutral (30%); Disagree (12%); Strongly disagree (11%)*
>
> *Question: Out of various Tablet PC based activities in this class, I'm enjoying the following one the most:*
> *A. Note taking and inking (18%); B. In-workshop problem solving (7%); C. Sketching work (9%); D. Collaborative work (14%); E. Combination of above (17%); F. None of the above (28%).*

6. Conclusion and future work

Tablet PC based instruction was implemented in a freshman engineering program at Virginia Tech in fall 2006. This was the first experience of the authors to use digital inking features in instruction. Two of the four authors (Lohani and Lo) coordinated EngE1024 and taught two large lecture sessions (~150 students per session) and never used the chalkboard for illustrating a concept by sketching or writing equations, unlike previous semesters. The digital ink/pen feature of the Tablet was effectively used for this purpose. Efforts were made to engage students in a large classroom by seeking input related to a course related concept or learning objective. The authors also used clickers for the purpose of formative assessment in large lectures and had to go back and forth several times between clicker software, OneNote, PowerPoint slides, etc. We are currently exploring the possibility of using Tablet friendly software like DyKnow for better

integration of the Tablets into instruction. From the students' perspective, electronic note taking and the ability to set up collaborative sessions for design/problem solving activities using the Tablet PC received favorable response. Towards the middle of the semester, some students complained of losing their digital pen (stylus) and had to pay ~$50 to get a new one. Therefore, advance warnings to students to this effect may be useful. In our exit survey, students were also asked what Tablet PC issues they thought needed to be researched further. The answers varied widely, but some of the most popular issues were OneNote, improving the reliability of the stylus, system cooling (several students thought their Tablet PCs became dangerously hot during use), battery life, the weight of the machine, increasing the available screen size, equipping the Tablet PCs with a higher end graphics card, and improving handwriting recognition. The authors are also exploring use of Tablet PCs in setting up collaborative sessions from remote locations.

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