AC 2008-1300: ENHANCING DISTRIBUTED LEARNING ENVIRONMENTS WITH TABLET PC TECHNOLOGY AND SOFTWARE

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Enhancing Distributed Learning Environments with Tablet PC Technology and Software

Abstract

The ability to gather and distribute knowledge effectively is at the heart of a healthy society. This paradigm has not escaped the educational realm as distance education programs have been established in many universities. Distance education programs are not intended to replace traditional face-to-face classroom instruction, but rather to expand the accessibility of knowledge to students where face-to-face instruction is not always possible or feasible. As universities expand geographically to other parts of the country and establish partnerships with institutions worldwide, it is clear that an effective design for creating distributed learning environments (i.e., distance education) must be established.

Distributed learning (DL) environments are at the heart of much of the course instruction at the Georgia Institute of Technology (GT). Currently, Georgia Tech Savannah (GTS) provides engineering education to students who are physically located at four different universities. One of the primary initiatives at GTS is to develop a blueprint for building a campus that utilizes computer-based technology to enhance the effectiveness of education in synchronous DL environments (i.e., live classroom instruction transmitted to remote sites).

This paper describes how Tablet PCs installed with Dyknow Vision software are being used in classrooms at GTS to improve student learning in a distributed learning environment. The Tablet PC is an attractive technology for use in synchronous distributed learning environments because of its mobility, and its ability to not only serve as an effective note taking device but also as a high-resolution course content viewing device. In this project, the instructor and students are given a Tablet PC to use during the semester, and surveys are administered to evaluate student attitudes about the use of Tablet PC technology as a means of receiving, processing, and learning course material. This paper discusses results from several distributed learning courses that were offered in the Spring and Fall semesters of 2007 to assess student attitudes on the use of Tablet PC technology. The work presented here provides useful insight into evaluating student learning experiences in distributed education in order to build effective synchronous DL environments.

Introduction and Motivation

A core goal of education is to deliver new concepts and ideas with the intent of promoting active learning and retention. At the heart of this information exchange is the interaction among instructors and students. Some of the most common activities of a traditional classroom include the presentation of written or electronic material, student note-taking and/or asking questions, and insightful problems and exercises posed by the instructor to promote student involvement in their learning process. These elements form the heart of most instruction and educational research has shown that each of these activities should be done with the intent to promote active and life-long learning[1].

Distributed Learning (DL) environments seek to implement established educational paradigms for effective student instruction into a unique classroom structure where the instructor and students may not be present in the same physical learning environment. Despite the technology that is available to deliver video and audio streams to remote classrooms, DL environments are still challenged in the area of promoting active learning and meaningful instructor-student and student-student interactions during a class session. Traditional DL classrooms suffer from several challenges in creating effective learning environments, and most of them center on two main issues: 1) poor delivery of lecture material and 2) constraints on creating in-class material for participant interaction and student assessment.

The delivery of lecture content is largely dependent on the quality of equipment and protocols that are in place, and this issue is not directly addressed in this paper. However, the reality is that poor video resolution in delivering class material to a distant classroom can be particularly damaging to a students' ability to clearly view and follow the lecture. Regarding instructor-student and student-student interaction, the remote separation of traditional DL classrooms largely limits all in-class interaction and responses to purely verbal interaction. Additionally, any in-class assessments (e.g., practice problems, exams, etc.) must be prepared in enough advance time to be sent to each remote site for the lecture period it is to be used. Completed assignments must then be collected and sent to the instructor after class via mail, email, or fax. This process limits the options for instructors who frequently use in-class activities and assessments to promote active learning.

The motivation of this paper is to investigate Tablet PC technology and software to improve the delivery of lecture material in a DL course as well as reduce some of the constraints on the instructors and students in creating effective learning experiences.

Tablet PC Technology and DL environments

Digital inking technology has added a remarkably useful input modality for instructors who rely on electronic delivery of lectures. In addition to the traditional mouse/keyboard input, digital ink allows appropriately configured computers to treat their screens as electronic whiteboards. The use of digital ink in the classroom is not entirely new as electronic whiteboards [2] and other forms of digital ink have been available for a number of years. Digital ink technology has provided flexibility to instructors in creating lecture content before, during, and after class. It has also been shown that digital ink may be used to create annotations on prepared lecture content as a substitute for physical gestures to highlight context and meaning during lecture [3, 4]. Several software programs, such as Classroom Presenter [5] and Dyknow [6, 7] emphasize the use of digital ink for integrating student and professor input during and after class. There have been a number of interesting studies investigating the uses of digital ink for promoting sound educational practices [8-22].

However, while digital inking technology is a wonderful benefit for traditional classrooms, it is absolutely essential for building effective distributed learning environments where much of the lecture delivery is electronic and computer dependent. In this spirit, an attractive technology for distributed learning environments is the Tablet PC[23]. Tablet PCs function in much the same way as traditional laptops with the added functionality of providing the user digital ink as an input modality for content creation directly on the Tablet screen. Tablet PCs are of particular interest in DL environments because of their mobility. Instructors and students may carry a Tablet PC to any learning environment and take advantage of a digital ink input modality.

With the support of HP and Microsoft, Tablet PCs are currently being evaluated for use in engineering courses at GTS. For this project, two remote sites have been equipped with Tablet PCs so the instructor and each student have a access to a Tablet PC during the lecture. To facilitate shared content between the instructor and students, the Dyknow[6] software program has been installed on all Tablet PCs. Dyknow software provides an Internet medium through which learning material can be freely exchanged between the instructor and students directly from the instructors Tablet PC to each student Tablet PC. Any learning material the instructor desires to present through Dyknow is presented directly on the Tablet PC screen of the student in an uncompressed format thereby solving any issues with pixel resolution and unclear presentations. Also, any student can create content on their Tablet PC and send it to the instructor Tablet PC for evaluation. The combination of the digital ink capabilities of the Tablet PC and the shared learning space created by the Dyknow software serve as the foundation for the DL environment that is evaluated in this paper.

Using Dyknow in Distance Learning

Two of the primary challenges in implementing DL courses involve constraints on lecture delivery and the creation of learning material designed for in-class student interaction and assessment. A related problem with electronic lecture delivery is that most traditional DL environments are only capable of sending a single video stream. In other words, while lecturing, either the lecture material being presented *or* video of the instructor may be broadcast to the remote site but not both. In this scenario, students at remote sites are subjected to nearly an entire lecture where they stare at lecture notes projected on a screen with no view of the instructor. Informal discussion with students has revealed the obvious fact that this type of interaction is far from ideal and has contributed to a generally negative attitude of instructors and students about DL environments. While newer protocols such as H.239 are helping to alleviate this problem, the vast majority of current DL environments at the sites associated with GTS are equipped with single video streams

However, with Dyknow, the lecture material for the class is transmitted directly from the instructor Tablet PC to the student Tablet PC, which frees the single video stream to be used entirely for transmitting video of the instructor to the remote sites. Now students may view the lecture on their Tablet PCs while watching the instructor projected at the front of the class. Additionally, the direct transmission of the lecture content from instructor to student Tablet PC greatly improves the presentation of the material and resolves issues with poor video resolution that normally exist.

Aside from aiding in the transmission of lecture content, the Tablet PC/Dyknow combination also allows for instructors to create “hybrid slides” which contain prepared lecture content as well as lecture content written by the instructor during class. The use of prepared lecture material (e.g., Powerpoint) is common in many engineering courses. However, many instructors still feel more comfortable with producing lecture content during the class (e.g., writing on a whiteboard). The combination of Dyknow and Tablet PC technology allows for a "hybrid" look at presenting a lecture. In this case, an instructor can prepare as many or as few slides as desired for lecture in Dyknow. During lecture, slides can be annotated, highlighted, or created completely in real-time. An example of this concept is presented in Figure 1. The figure shows a slide that was prepared with some electronic text as an introduction to a new concept. However, the instructor then uses the remaining parts of the slide to write out content related to this concept. Additionally, the instructor has written annotations on the slide to highlight certain key points being made during the lecture.

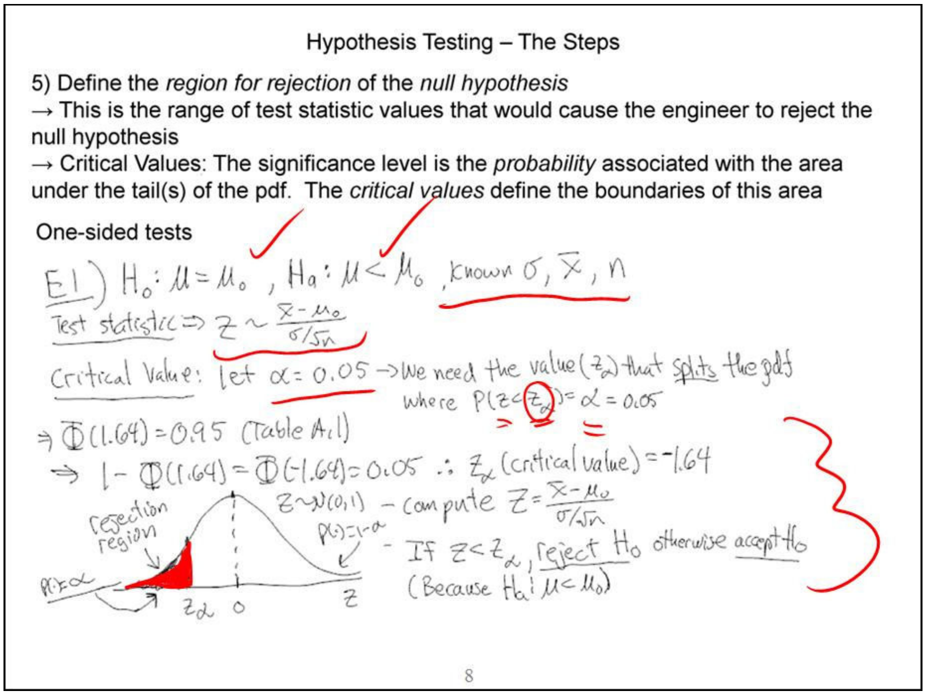


Figure 1: Hybrid slide in Dyknow

The other main challenge in traditional DL environments is the difficulty in allowing for classroom interactions between the instructor and students, and among students. Creating an active learning environment requires a constant cycle of instructor-student and student-student feedback and interaction on class concepts and material. The Dyknow software interface grants class participants several options for interaction. One feature involves the ability for the instructor to poll the class on a topic and display the results for the class to see. Figure 2 shows a pie chart that is the result of a class poll for a question relating to the slide. The students responses are anonymous and do not require raising hands or verbal response (things that are difficult enough to solicit in a traditional classroom and even more difficult in a distributed classroom). Additionally, each student can see where their thoughts and views fit within the rest of the class.

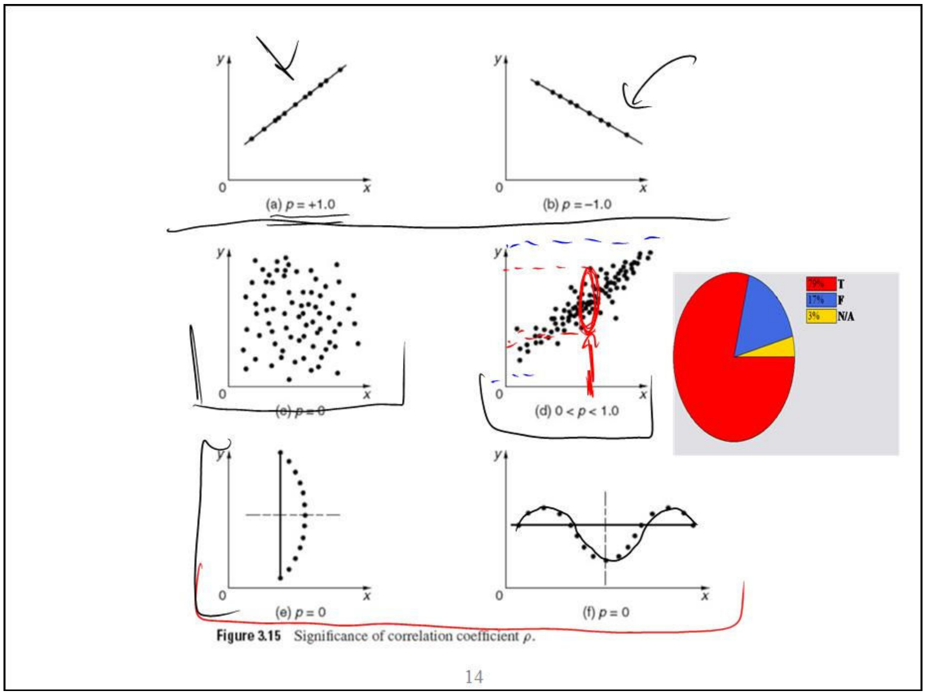
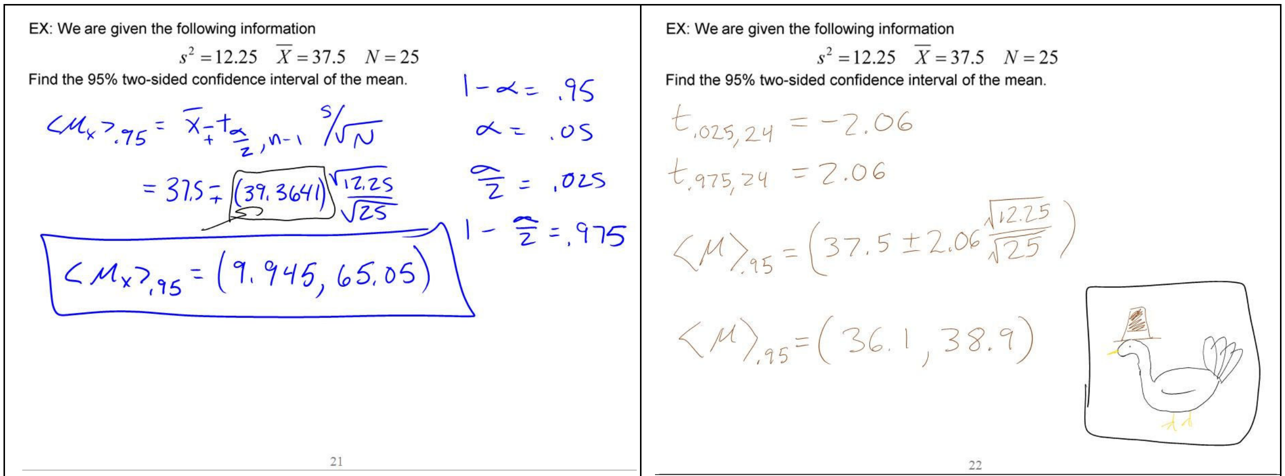


Figure 2: Class poll in Dyknow

Another type of interaction of particular interest in engineering disciplines is the ability to create practice problems, shared diagrams, and other types of technical content during a class lecture. Dyknow software allows for an instructor to create exercises that each student must solve and submit to the instructor for assessment. The instructor can view each student response on the Tablet PC and then assess which students are having problems. Figure 3 illustrates one particular example of an instructor interacting with the class on a practice problem. In this example, a problem was presented to the class through Dyknow and each student was required to work the problem on their Tablet PC. In Figure 3a the student has answered the problem incorrectly. The instructor can then show the class this incorrect response without revealing the identity of the student who submitted it. The figure shows how the instructor clearly indicates where the error has occurred, and this then becomes a point of discussion in the class. After the discussion, the professor chooses a correct response to show the class as shown in Figure 3b. Note that the student who has a correct response also feels the need to express another side of their creativity in drawing a turkey in the lower portion of the slide. While this clearly has nothing to do with engineering, it does suggest that the student feels comfortable in the class environment that has been created. Additionally, upon showing the correct solution to the class it served to help stimulate other student-student interaction across the remote sites.



(a) (b)

Figure 3: Student answers to class problem: (a) Incorrect Response (b) Correct Response

Implementation

With support from HP, Microsoft, and GTS, Tablet PCs equipped with Dyknow software were installed in two remote classrooms for the Spring and Fall semesters of 2007. A classroom at GTS was fitted with 15 Tablet PCs while a cart of 20 Tablet PCs was used in a classroom at one of the remote campuses served by GTS. While GTS can service up to 4 sites during a DL lecture, courses used for this project in these two terms were structured in a way that only required connections between the two remote sites where the Tablet PCs were available. The Tablet PCs and Dyknow software were used for all basic classroom activities including lecture delivery, in-class exercises, and student polling as described earlier. Additionally, for the Spring 2007 semester the Tablet PCs were used for exam administration and collection. Students were instructed to download an exam from WebCT in Windows Journal format (an electronic notebook that is standard software on Microsoft Windows Tablet PC editions), take the exam on their Tablet PC and upload the exam to WebCT for the instructor to grade. Interruptions in internet connectivity led to this particular implementation not being used for Fall 2007. The students were not required to take notes, but the Dyknow software allowed for private notes and annotations to be made by the students to accompany the instructor presentation. All lecture content from the in-class sessions were stored electronically and made available to students outside of class through WebCT.

Evaluation

Evaluating the usefulness of educational technology is always a challenging task. Ideally, the most critical analysis area of educational technology is its impact on student learning. It is always of interest to note whether various educational techniques are leading to improved student retention and performance. However, analysis of these issues is challenging due to the number of variables that are difficult to control such as assessing the capabilities of students from course to course, determining consistent lecture practices for comparison, and a host of other factors. While the issue of learning impact is still important at GTS, this paper will focus on presenting results designed to interpret student attitudes regarding the technology implementation involving Tablet PCs and Dyknow versus their traditional DL environments.

One valid issue when evaluating technology that users are not familiar with is the "novelty" factor where subjects can offer overly exuberant responses to something based solely on the fact that it is new to them. To help alleviate some of this, three surveys were administered over the course of each 17-week semester. A pre-survey was given near the beginning of the semester to get an understanding of the demographic of the students participating in the project. A mid-survey (around week 8 or 9 of the semester) and a final survey (at the end of the semester) were also administered to assess student attitudes about the project. The mid-survey and final survey were structured to share many of the same questions in an attempt to curb any unwarranted enthusiasm (or criticism) by the students. It is assumed that by the time students have spent 17 weeks with the technology it is no longer considered "novel" and a fair assessment can be interpreted from the responses.

Student Makeup

During the Fall and Spring semesters, 46 students were exposed to the Tablet PC/Dyknow implementation for DL environments at GTS. Class sizes for each course were monitored to ensure that each student would have access to a Tablet PC. The number of student responses varied from 43-45 for the three surveys administered over the two semesters. Of the students surveyed, approximately 18% were Civil Engineering, 39% were Electrical Engineering, 5% were Computer Engineering, and 39% were Mechanical engineering. The vast majority had taken at least one distance learning course prior to participating in the study or were enrolled in another distance learning course concurrent with the Tablet PC course. Additionally, 93% of the surveyed students were full-time students (i.e., registered for 12 hours or more).

Regarding computer knowledge and skill, students were asked to provide a personal assessment of their confidence in learning to use new computer applications. Their responses were collected on a scale of 1(Not Confident) to 4 (Extremely Confident). Overall, the respondents had an average score of 2.72 indicating moderate confidence in their abilities to learn and use new computer applications.

Student Evaluations – Participation History

In addition to assessing student attitudes about the technology, it was also of interest to determine the level of participation that students generally have in their classes and to determine, if possible, the effect of technology on class participation. Students were asked to evaluate the frequency with which they ask questions, volunteer to answer questions, and take written notes in class. The scores for their responses were tabulated based on a scale of 1 (Never) to 6 (Very Frequently). Table 1 shows the average response of all participants. Overall, the results indicate that students only rarely or occasionally ask questions or volunteer to answer questions during class. This is not entirely surprising to most instructors although the results do show a slight increase in student participation on the Mid and Final surveys. However, this could be a function of the instructor or the Tablet PC implementation. Of particular interest from this set of questions was the response to taking written notes. Prior to attending the class, the students indicated a very strong history of note-taking whereas in the Tablet PC equipped classroom, there was a clear indication that this was not the case. A possible explanation for this could be that the lecture notes were presented directly on the student Tablet PCs. While Dyknow does allow for students to take private notes, it would seem that there was a strong preference for students to simply follow along with the lecture rather than take any notes. It is unclear at this point whether this practice benefited or hindered student performance.

Table 1: Participation History

How Frequently Do You:	*Pre-Survey (N=44)*	*Mid-Survey (N=43)*	*Final Survey (N=45)*
Ask the instructor questions during class	3.68	3.75	3.76
Volunteer to answer a question during class	3.73	4.04	4.07
Take written notes during class	5.41	3.76	3.70
1. Never, 2. Very Rarely, 3. Rarely, 4. Occassionally, 5. Frequently, 6. Very Frequently			

Student Evaluations – Comparisons of Distance Learning Implementations

Another part of the evaluation of student attitude regarded how students viewed the use of Tablet PC technology in their DL environment compared to their experiences with traditional DL environments, i.e., those without Tablet PCs. On the Mid and Final Surveys, students were asked to evaluate several aspects of DL classrooms including lecture delivery, student-instructor interaction, and the ability to follow lectures and clearly view the lecture material. The scores were recorded on a scale of 1 (Poor) to 5 (Excellent) and the average scores are presented in Table 2.

Table 2: Student responses to DL Implementations

	Prior DL Implementations		Tablet PC Implementation	
How would you rate the following	*Mid-Survey (N=43)*	*Final Survey (N=45)*	*Mid-Survey (N=43)*	*Final Survey (N=45)*
Lecture Note Delivery	2.44	2.35	4.25	4.40
Interaction with instructor during lecture	2.20	2.10	4.05	4.07
Ability to follow lecture in class	2.33	2.29	4.00	4.19
Ability to participate in class discussions/learning	2.18	2.35	4.19	4.21
Ability to clearly view lecture notes	2.34	2.11	4.58	4.61
Overal Impression of DL courses	2.16	2.34	3.95	4.25
1. Poor, 2. Fair, 3. Good, 4. Very Good, 5. Excellent				

What should be pointed out about the results in Table 2 is that the students were not asked to directly compare prior DL implementations with the Tablet PC implementation. Each implementation is rated individually, and the comparison of the results clearly indicate that student attitudes regarding the Tablet PC implementation are higher than those of DL implementations that rely only on video and audio transmission of lecture content. What is also clear is that the students seem to feel that traditional implementations of DL environments are generally not very good.

Student Evaluations – Response to Tablet PC Implementation

While it was clear that the students felt the Tablet PC implementation created a better DL environment than traditional DL implementations, it was also of interest to determine the attitude of students regarding the impact on learning from their perspective. The intent of this series of questions was not to analyze the specific performance of students (e.g., grades on exams and quizzes) but rather the student's impressions of their learning experiences. Table 3 shows student responses to this line of questions with average scores using a scale from 1 (Strongly Disagree) to 5 (Strongly Agree).

The results in Table 3 show that the Tablet PC implementation contributed to improving student attitudes about taking distance learning courses. Additionally, students indicated an overall agreement that they felt more involved in lecture than in other DL courses as well as a strong preference to see other DL courses use Tablet PC technology. When asked to compare their feeling of involvement in the Tablet PC enabled DL courses and traditional non-DL courses the final result indicates that students probably still prefer to take non-DL courses. Additionally, the response to whether students felt more involved in their learning process produced results close to agreement but still indicating some indecision. One potential explanation for this could be linked to the decrease in student note-taking indicated in Table 1. Given the strong prior history of note taking indicated in the pre-surveys it is possible that some students did not feel as involved because they were not taking notes as frequently.

Table 3: Student Response to Tablet PC implementation

Regarding the Tablet PC and software technology implemention for DL courses	*Mid Survey (N=43)*	*Final Survey (N=45)*
My overall perception of distance learning has improved.	4.34	4.18
I feel more involved in the lecture than in other distributed learning courses.	4.39	4.04
I feel more involved in the lecture than in other traditional courses (i.e., non-distance learning courses).	4.13	3.66
I feel more involved in my learning process.	3.93	3.80
I would like to see more DL courses use this implementation.	4.56	4.44
1. Strongly Disagree, 2. Disagree, 3. Undecided, 4. Agree, 5. Strongly Agree		

Students were also asked to assess their attitude about how the use of Tablet PCs in the DL environment had impacted their overall performance in the class. Their responses were averaged on a scale from 1 (Strongly Negative) to 5 (Strongly Positive). In the survey, the question was clarified to ensure that the students were aware that a negative response indicated that the Tablet PC implementation had in some way hindered their ability to perform well and a positive response indicated that the Tablet PC implementation and helped them in some way. Table 4 shows that, overall, students felt that Tablet PC implementation had in some way had a slightly positive benefit to them. While this result should not cause undue optimism, it is important to at least note that the students did not feel the Tablet PC implementation was a hindrance to their learning process.

Table 4: Student attitude on performance impact

	Mid-Survey (N=43)	*Final Survey (N=45)*
Indicate how the Tablet PC implementation has impacted your overall performance in this class	4.07	4.16
1. Strongly Negative, 2. Slightly Negative, 3. No Impact, 4. Slightly Positive 5. Strongly Positive		

Student Comments

In the final survey, students were asked to make free comments about their experiences with the Tablet PC. Generally, negative comments about the implementation centered on the interruptions with the internet connection or problems with the Dyknow server that caused the Tablet PC implementation to not work properly. Additionally, there was some disagreement among students regarding the issue of taking notes in the class. Some students preferred to simply follow along with the lecture and did not concern themselves with note-taking. Other students felt that they would have learned the material better if there had been a more effective means for them to take notes in the Dyknow interface. Positive remarks about the Tablet PC implementation largely focused on the lecture presentation through Dyknow and the increased opportunities to interact with the instructor through abilities such as submitting class exercises through Dyknow for immediate instructor feedback.

A sample of the student comments is shown below

"The note taking process should be a little bit more student involved. The actual act of writing things down really helps students to absorb information because they must hear, comprehend, interpret, and then write the information down on paper, or Tablet pc." (*Spring 2007 student*)

"I really enjoyed the Tablet PC idea. For the past year I have regretted not getting one as soon as I started college." (*Spring 2007 student*)

"I liked that the professor could ask questions and have us submit answers. It caused me to pay more attention than I normally would. I think I also grasped the concepts better by actually doing them during class." (*Spring 2007 student*)

"The Dyknow interface allows students to actually LISTEN to what the instructor is saying without scrambling madly to write stuff down and missing important point in the process. I would highly recommend it!" (*Spring 2007 student*)

"It would be great if we sometimes had access to the tablet PCs outside of class" (*Fall 2007 student*)

"The Tablet PC's seemed to be better than other distance learning courses, but the only thing is the small stuff like losing your internet connection during the middle of a lecture kills your train of thought...Being able to participate in examples during class helps out a good bit because if you think that you know something and are wrong about it then you find out from working the example and getting the answer before you leave so when studying you don't teach yourself the wrong way." (*Fall 2007 student*)

"LOBBY TO MAKE OTHER CLASSES USE TABLET PCs!! It worked very well. Not only was having all the notes readily available great, but working problems in class with you giving feedback and showing popular incorrect answers was nice too. I'm actually getting a tablet pc for Christmas because of this class, no joke." (*Fall 2007 student*)

Concluding Remarks

Student comments and the survey results show that the Tablet PC implementation in DL environments is not a perfect solution. However, the results also clearly indicate that the interaction between the instructors and students are greatly improved in this implementation, which can contribute to improving the creation of active learning environments in distributed education. The data presented here represents a subset of a larger database that is still under analysis. Also, future research is continuing to seek out models for objectively assessing the learning impact of the Tablet PC implementation on students in DL courses.

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