TABLET COMPUTERS AND INKSURVEY SOFTWARE IN A COLLEGE ENGINEERING STATISTICS COURSE: HOW ARE STUDENTS' LEARNING AND ATTITUDES IMPACTED?

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Abstract

This paper presents a study that sought to use tablet personal computers (PCs) with the InkSurvey software for improving the instruction of a probability and statistics course for engineering students at the Colorado School of Mines (CSM). The InkSurvey software was designed in the physics department at CSM for use with tablet PCs and has the benefit of supporting anonymous student-teacher interaction during instruction. Using InkSurvey, an instructor can ask a question to which students may electronically respond. The instructor can then view the anonymous responses and provide formative feedback during class. In this investigation, a pre and post attitude survey and a pre and post statistics concept inventory was administered to students in six sections of a probability and statistics course for engineers. Five instructors taught the various sections using different approaches, all of which included the tablet PCs with InkSurvey. Across sections, the students' attitudes became more negative towards statistics over the course of the semester and, based on a statistics concept inventory, there was no evidence to support that their understanding of the subject had improved. This paper explores the potential explanations for these bleak results.

Introduction

The current generation of college students grew up with technology and embraces it both as a social medium and as an academic tool. Because of the appeal of technology to the current college age students, educational researchers and college instructors have been exploring new methods for using technology to enhance the learning process. The level of use varies by instructor and institution.

Georgia Tech began the Classroom 2000 project in the 1990s, with the intention of investigating diverse approaches for incorporating technology in the classroom.[1] This project continues today under the revised name, eClass.[2] Classroom 2000/eClass was designed to investigate the idea that students are able to devote more attention to content when they do not need to focus on copying notes. Other schools, even high schools, have selected to adopt specific technologies, such as the tablet PCs for widespread instructional use. For example, secondary school districts in Ontario are using tablet PCs to almost completely replace paper in the classroom.[3] This became possible as a result of the introduction of pen-based entry, which was pioneered in 2003.[4] Students can now take electronic notes on subjects, such as mathematics, science and engineering, which are heavily symbolic and for which the traditional keyboard is ineffective. These notes can be altered and updated over several days or weeks through an editable digital file. With a pen-based tablet PC, students are able to start with a file of key concepts and add notations to enhance their own understanding, limiting their distractions and potentially increasing real time comprehension. Instructors can also build electronic lectures over several days, updating, storing and distributing the revised file, and eliminating the need to erase the notes from the whiteboard before the next class enters the room.

Although there are many articles that argue for the appeal of tablet PCs and their potential benefits to the classroom, there are few published studies that investigate their impact on learning. The eClass experiment concluded that students prefer the tablet PCs to alternate technological solutions (such as the exclusive use of overheads), and that the electronic notes provided benefits for students who missed class. Additionally, Georgia Tech found that more than 16% of student accesses of

the notes were after the course had concluded.[2] There is also evidence from prior research that traditional lecture fails to improve students' statistical concept understanding when measured using a pre and post methodology.[5]

The focus of the study reported here is to examine the first semester implementation of using tablet PCs with the InkSurvey software, in a statistics course at Colorado School of Mines (CSM). The InkSurvey software was designed in the physics department at CSM under an HP Technology for Teaching grant.[8] Using InkSurvey, instructors can ask questions and each student can view and respond to the instructors question using a tablet PC. The instructor can view the student responses, which are anonymous, and provide immediate feedback to the class during instruction. One of the measurement instruments used in this investigation was the statistics concept inventory, which was developed by researchers at Purdue University and the University of Oklahoma. The validity of the statistics concepts inventory has been established over several semesters of implementation prior to its use in the current investigation.[6] An attitude survey was also used to measure students' attitudes with respect to statistics.[7] There were six sections of Probability and Statistics for Engineers during the first semester implementation and five teachers. One instructor taught two sections. This paper discusses the five different approaches to using the tablet PCs in the classroom and provides the results of the first semester of implementation.

The research questions discussed here are:

1. How did the different instructors select to use the tablet PCs and the InkSurvey software during instruction?
2. Did the students' attitudes toward probability and statistics as measured through the attitude survey change over the semester in which the tablet PCs were used in the classroom?
3. Did the students' understanding of probability and statistics change, as measured through the concept inventory, over the course of the semester in which the tablet PCs were used in the classroom?

Methods

This section includes the design of the study, a description of the participating population, and a description of the data that was collected over the course of the semester.

A. Design

There were six sections of Probability and Statistics for Engineers during Spring 2011 and five instructors. Instructors received two, one-hour training sessions on using tablet PCs with the InkSurvey software prior to the start of the Spring semester. Instructors were provided with tablet PCs which they could take home in order to prepare for instruction. Additionally, the course was taught in the tablet PC classroom which was equipped with forty tablet PCs. Each class was limited to 40 students, so each student had access to a tablet PC during instruction. The students were not able to take the tablets with them at the end of class. A graduate student was assigned to support the instructors with the software and technology during the first few weeks of the semester. The five instructors had varying titles and levels of teaching experience, which are summarized in Table 1.

As is reflected in Table 1, there were two graduate teaching fellows or graduate students who had the appropriate background in probability and statistics to teach the course. These students had expressed an interest in learning how to teach at the college level. Both had taught this course in the previous semester. There were two adjunct or part-time teaching faculty who taught the course. One had three years of experience and had previously taught this course four times; the other had six years of experience, but had never previously taught this course. A Professor at CSM with 16 years of teaching experience was the coordinator for the course and had previously taught the course six times. She was also responsible for providing guidance and answering questions for the other instructors throughout the semester.

Table 1. Summary of the instructors' teaching experience.

Instructor	Title	General Teaching Experience (years)	Number of Times had Previously Taught Probability and Statistics (semesters)
A	Graduate Teaching Fellow	1	2
B	Graduate Teaching Fellow	1	2
C	Adjunct	3	4
D	Adjunct	6	First time
E	Professor	16	6

Instructors A, C, D, and E used the InkSurvey software as a method to ask their students questions during class and Instructor B used the software as a way for students to ask the instructor questions during class. Instructor E used the software every day, Instructors A, B, and C used the software at least once a week, and Instructor D used the InkSurvey software approximately once every two weeks. Instructors D and E were the only instructors that used the tablet PCs for purposes other than the InkSurvey software. Instructor D used the tablet PCs at least once a week, so students could get experience with real data problems and Instructor E provided lecture notes online through the Blackboard software system and students could view the notes on their tablet PC during class or from their personal computers out of class.

B. Participating Populations

The population consisted of the students enrolled in one of the six sections of Probability and Statistics for Engineers during Spring 2011. Probability and Statistics for Engineers is a junior level course at CSM and is required of the majority of science and engineering majors at CSM.

C. Student Attitude and Content Surveys

All students were asked to respond to both an attitude and content survey in pre and post format online. As intended, the students responded to the post surveys during the last couple of weeks of the semester, but due to software difficulties with the online instruments the pre surveys were completed approximately a month into the semester.

The attitude survey consisted of 29 statements relating to an individual's attitude towards the course and towards the field.[7] The attitude survey uses a five point Likert scale with the following categories: strongly agree, agree, neutral, strongly disagree, and disagree. Each participant's responses to the statements on the attitude survey was mapped to a numerical value between one and five, with higher values reflecting more positive attitudes. In other words, a positively worded statement is scored a five for strongly agree, a four for agree, a three for neutral, a two for disagree, and a one for strongly disagree. A negatively worded statement is scored a five for strongly disagree, a four for disagree, a three for neutral, a two for agree, and a one for strongly agree. Participant's total scores were calculated by summing the score for each answered statement.

The content survey consisted of 38 questions relating to content that was covered over the semester including questions relating to probability, inference, descriptive, and graphical.[6] Questions on the content survey were scored a one for a correct answer and a zero for an incorrect answer. Participant's total scores were calculated by summing the score for each answered question. Students were also asked to provide feedback about their confidence in their answer for each question. The categories included: high, moderate-high, moderate, low-moderate, low, and total guess. Their confidence level for each question was mapped to a numerical value between zero and five, with a higher value reflecting more confidence in their answer.

D. Student Feedback

Instructor E asked the students in her section to provide feedback on the use of the tablets in the

classroom approximately one month into the semester. Feedback was provided with the use of the InkSurvey software and by design of the software all student responses were anonymous. Students responded to one open ended question during class and responses were placed into one of three categories: positive, negative, or neutral.

E. Instructor Interviews

All instructors were asked to respond to a set of open-ended questions approximately halfway through the semester. The questions were divided into two topics: tablet PCs and the InkSurvey software. Interviews were conducted by a teaching assistant either by email or in person. Comments from the instructors are summarized in this article.

F. Performance

A comparison of finals given in Spring 2009 and Spring 2011 was conducted to further assess the impact of the tablet PC and the InkSurvey software in the probability and statistics course. In the spring of 2009, one of the participating instructors had taught the probability and statistics course using the same notes but without the tablet PCs and InkSurvey. Given this, student performances on the final in Spring 2009 (before the use of the tablets and InkSurvey) were compared to student performances in Spring 2011. The 2009 data provided a natural control group. The final from Spring 2011 was based on the Spring 2009 final. The finals were identical except for three problems were removed from the Spring 2011 final due to length concerns. An adjustment in scores was made to the Spring 2009 finals by removing the last three questions.

Results

This section will include the results of the student attitude and content surveys, student feedback, and instructor interviews.

A. Student Attitude and Content Surveys

In order to measure change from pre to post assessment for the attitude and content survey, a Wilcoxon Signed Rank test was performed on the responses to determine if there was a statistically significant difference between the pre and post scores. A Wilcoxon Signed Rank test was used due to the existence of outliers in many of the samples. If outliers were present in the sample, the tests were performed with and without the outliers and any differences in the conclusions at a 5% level were also examined. Only participants who completed both a pre and post attitude and a pre and post content survey were included in this analysis.

All statistical analyses were completed in R, a free statistical software available online, and the results of this analysis are displayed in Tables 2 and 3 for the attitude and content survey, respectively. As indicated in Table 2, the only statistically significant results found for the attitude survey were for Instructors D, E, and overall instructors. In all significant cases, there was a negative change in the attitudes over the semester. Table 3 indicates a statistically significant result for Instructors A and D. There was a positive change in content for Instructor B and a negative change in content for Instructor D. After removing outliers, a statistically significant positive change in content was also found for Instructor B (p-value: 0.0039). Instructors A, B, C, E, and overall had a statistically significant positive change in their students' confidence in their solution at α=0.05 (p-values: 0.0000, 0.0063, 0.0011, 0.0002, and 0.0000, respectively). Instructor D had a negative change in his students' confidence in their solutions, although the result was not significant at α=0.05 (p-value: 0.0768).

Table 2. Results of attitude survey by instructor.

Instructor	Sample Size	Pseudo Median	p-value
A	16	2.75	0.5308
B	27	-0.75	0.7862
C	10	-4.25	0.0977
D	33	-11.25	0.0000*
E	18	-5.25	0.0104*
All	104	-5.00	0.0001*

* indicates significance at α=0.05

Table 3. Results of content survey by instructor.

Instructor	Sample Size	Pseudo Median	p-value
A	17	3.75	0.0002*
B	25	2.25	0.0747
C	12	3.75	0.0625
D	31	-2.75	0.0301*
E	17	0.75	0.6392
All	102	1.00	0.0968

* indicates significance at α=0.05

B. Student Feedback

There were 23 student responses received regarding the use of tablets in the classroom by Instructor E. The students were asked to respond to the following question: Do you like the use of the tablets in the classroom? Why or why not. Responses were placed into 3 categories, positive/yes, negative/no, and neutral/undecided. There were 13 positive responses, 7 negative responses, and 3 students who were undecided. Of the students with a positive response, one student liked the variety in the teaching, two students liked the access of the lecture notes, and six of the students liked the InkSurvey software. Many of the students that mentioned the software indicated they liked the immediate feedback provided by the instructor during lecture. Of the students that indicated a negative response, three students liked the traditional teaching method better and four mentioned the tablets were a distraction. The students that were undecided indicated they liked the idea of the software, although they felt too much class time was wasted using the software.

C. Instructor Interviews

Instructors were asked to respond to questions regarding the tablet PCs and the InkSurvey software. Tables 4 and 5 include a summary of instructor responses regarding the tablet PCs and InkSurvey software, respectively.

Three of the instructors, A, B and C, felt that the tablet PCs wasted too much class time. Instructor A explained that the tablet PCs were a distraction to the students, and suggested that they may be more useful in an applied course. Instructor A further indicated that the software was engaging to students, but he found reading and responding to the responses to be too time intensive. Instructor B also found the tablets to be a distraction to students, resulting in students not paying attention to instruction. Instructor C felt that the tablets would be more appropriate to courses that are external to mathematics. Instructor D found that the software was useful, but time consuming. He liked using the tablets and felt the tablets provided the students with the opportunity to complete applied problems during class and experience hands-on learning. Instructor E believes that attendance in her course had improved as a result of the engagement that the tablet PCs provided. She further found the opportunity to immediately respond to students' errors as reflected through InkSurvey useful for informing instruction. All of the instructors felt that the tablets could be useful, but only if the instructor had a desire and dedication to learning the technology. All of the instructors also acknowledged the potential benefits of providing immediate feedback to their students based on the responses received through InkSurvey.

Table 4. Summary of instructor comments regarding the tablet PCs.

Instructor	Are the tablets useful in the classroom?	Have the tablets help improve your instruction?	Are the tablets a good use of time?	Would you use the tablets in future courses?	Would you recommend the tablets to other instructors?
A	No	No	Sometimes	Depends	Depends
B	No	No	No	No	No
C	No	Not sure	No	No	Depends
D	Yes	Yes	Yes	Yes	Depends
E	Yes	Yes	Yes	Yes	Yes

Table 5. Summary of instructor comments regarding the InkSurvey software.

Instructor	Is the InkSurvey software useful in the classroom?	Has the software help improve your instruction?	Is the software a good use of time?	Would you use the software in future courses?	Would you recommend the software to other instructors?
A	Depends	Depends	No	Depends	No
B	No	Not sure	No	No	No
C	Sometimes	Not sure	Sometimes	No	Depends
D	Yes	Yes	Yes	Yes	Depends
E	Yes	Yes	Yes	Yes	Yes

D. Performance

The Spring 2011 final exam was based on the final exam from two years previous. Three problems were removed due to length concerns, and the remaining problems were identical. Instructor E taught both semesters, and provided the exams from each for comparison. The 2009 scores were adjusted by removing the questions that were not asked in 2011.

Table 6. Summary of final exam results.

Year	Sample Size	Mean
2009	41	67.5
2011	33	64.8

There was no statistically significant difference between the 2009 final and the 2011 final (p-value = 0.5321). Adjustments in data, including removing a single outlier from 2009 and comparing the non-reduced exam scores did not produce different results. The results of these comparisons indicate that students who used the tablets did not perform statistically different from the students who participated in a traditional lecture format.

Discussion

This article describes the first semester implementation of the InkSurvey software in a probability and statistics course for engineers at CSM, which is a required course for most engineering and science students at the university. The five instructors teaching probability and statistics during Spring 2011 used the tablets and software in addition to their lecture to provide immediate feedback to their students. All instructors incorporated the tablets and software differently into their courses and this paper discusses the five approaches for using the technology in their classroom.

The results of the pre and post attitude and content survey indicate an overall negative change in the students' attitudes towards statistics and no statistically significant change in content knowledge. Due to the lack of a control group, the results of the pre and post instruments cannot be directly attributed to the use of the tablets PCs with InkSurvey software in the classroom. Additionally, these results may be partially explained by the failure to collect the pre-data early in the semester. By the time the students completed the pre-attitude and pre-content assessments, their attitudes and knowledge may have been impacted by the previous month of instruction.

In instructor E's classroom, feedback was also anonymously collected from students concerning their experiences with the tablet PCs. The student feedback regarding the use of the tablet PCs in the classroom indicates that 57% of students who responded to the survey liked the tablet PCs in the classroom, 30% disliked the tablets, and 13% were undecided. This is aligned with results concerning students attitudes towards tablets reported at other institutions.[9,10,11] The instructor who collected these results used the tablet PCs and software every class and provided immediate feedback to her students. In this same class, however, there was a statistically significant decline in the students' attitudes towards probability and sta-

tistics and there was no indication on the content exam that the students' knowledge improved over the course of the semester, an alarming finding. Additionally, a comparison of final exams from a prior implementation of the course in 2009 to that of 2011, also failed to indicate any significant difference in students' performances. These findings support the assertion that the manner in which the tablet PCs were used in this classroom was not effective for improving student performance or attitudes when compared to a lecture format.

Throughout this investigation, we found that the instructors with the most teaching experience were more open to the idea of using the tablet PCs and the InkSurvey software in the classroom. These instructors used the tablets more frequently and had a positive attitude toward the technology. However, these same instructor's students' displayed negative changes in their attitudes towards statistics.

One concern that has emerged from this investigation is why the results are so bleak. One hypothesis is that change, any change, takes time before it is accepted. The initial implementation of a major instructional change, such as the use of tablet PCs in the classroom, may be greeted with resistance. This resistance may exist at both an instructional and at a student level, as was witnessed here. Given this, a follow-up investigation was completed in the fall of 2011, and the analysis is underway. We anticipate updating the conclusions drawn here in future papers.

In response to our original research questions:

1. How did the different instructors select to use the tablet PCs and the InkSurvey software during instruction?

There were five instructors that taught probability and statistics. Four of the instructors used the InkSurvey software as a method to ask their students questions during class and one instructor used the software as a way for students to ask questions during class. Only one instructor used the software every day, three instructors used the software at least once a week, and one instructor used the software approximately once every two weeks. Only two instructors used the tablet PCs for uses other than the InkSurvey software. One instructor used the tablets for data analysis and the other instructor provided lecture notes online for the students to access on the tablets during class.

2. Did the students' attitudes toward probability and statistics as measured through the attitude survey change over the semester in which the tablet PCs were used in the classroom?

We found no evidence to suggest a positive improvement in the students' attitudes toward probability and statistics. In fact, the evidence is stronger that, for at least two classes, their attitudes declined.

3. Did the students' understanding of probability and statistics change, as measured through the concept inventory, over the course of the semester in which the tablet PCs were used in the classroom?

As was the case with the previous research question, our results did not support a positive change in students understanding of probability and statistics.

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