AC 2010-1453: ASSESMENT OF STUDENT LEARNING WHEN USING TABLET PCS AND THE SOFTWARE DYKNOW

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Assessment of Student Learning When Using Tablet PCs and the Software DyKnow™

Abstract

Many advances in technology in software and hardware promise to improve student learning. Of the more promising technologies to come onto the market recently were the tablet PC and an interactive-education software package called DyKnow. This combination of software and hardware offered to solve many of the problems that students and instructors face in a regular classroom such deficient student understanding, lack of student participation, and incomplete classroom notes.

An objective of this work was to measure student learning comparing two equivalent groups of engineering students in their first semester of thermodynamics. One group was taught using a conventional lecture style, while the other group utilized tablet PCs and the DyKnow software. Both groups were given the same final exam, at least, so their respective levels of understanding could be assessed and compared. These experiments were conducted for three consecutive semesters.

Results of both groups were compared by selecting pairs of students with similar GPAs and applying statistical methods on the two groups' scores. The results from all semesters were very similar. Students using tablet PCs and the DyKnow system did not show better understanding of the subject than the students in the traditional classroom.

Introduction

Traditionally, three steps are involved in the teaching and learning of engineering concepts. First, scientific laws and principles are explained using illustrations, charts and equations. The instructor then demonstrates the application of the laws and principles to engineering problems. Finally, student understanding is enhanced and evaluated using reading assignments, homework, quizzes, and examinations. The first two steps are usually delivered in a lecture format by engineering instructors using markers on a whiteboard, chalk on a chalkboard or Power Point slides. This type of lecture will be called a traditional lecture in this work.

Research in education has shown that traditional lectures have limited success in helping students learn science and engineering courses[1]. Lectures in these subjects usually deliver complex material at a rapid pace while students are trying to understand and take good notes. In many instances neither the student is able to understand the instructor well, nor does he or she take good notes. According to Wieman and Perkins[2] the retention rate may be as low as 10% after just 15 minutes of lecture for a nonobvious fact that is presented in a lecture. In another experiment conducted by Hrepic et.al[3], revealed that students even in an ideal lecture setting may: 1) hear and record information incorrectly, 2) attach the wrong meaning to correct statements and, 3) make unjustified extrapolation leaps or inappropriate generalizations.

Another common problem in a traditional lecture is that few students participate in classes. Many students are afraid to raise their hands for fear of criticism or lack of confidence. When instructors ask questions in order to engage students in the subject under consideration, it is not uncommon for only a few students to participate regularly. These students are usually the students who know how to study and obtain a high grade at the end of a class, regardless of the quality of lecture. In general students who really need to participate are the ones that remain silent.

To improve on the traditional methods, many researchers[4,5,6,7,8,9,10,11] have investigated the use of tablet PCs and a variety of software in science, technology, engineering and mathematics (STEM) courses. The intent of introducing the technology was to improve student learning, usually through four practices: (1) engaging students in active learning, (2) providing prompt (nearly instant) feedback to the instructor of student understanding of course material, (3) relieving students of the burden of the task of note taking so students can focus on the course content, and (4) providing archived course material that students can access remotely. Essentially, these four practices embody many of the "seven principles of good practice in undergraduate education" given in Chickering's and Gamson's frequently-cited paper[12].

One of the more promising pedagogical technologies to come onto the market recently was the interactive-education software package called DyKnow running in tablet PCs. This combination of software and hardware offers a solution to many of the problems that students and instructors face in a regular classroom. It facilitates the implementation of the four practices mentioned above. For example, the Dyknow software provide tools to create polls and quizzes that can be instantaneously submitted (anonymously if desired) by the student to the instructor. The instructor can review and discuss some of the student work immediately, providing instantaneous feedback. This should help instructors engage all students in the subject under consideration.

The DyKnow software also relieves students of note taking by transferring all the instructors' notes to the students' computers instantaneously. Thus, students can focus on the instructor's presentation rather than on taking notes. Complete instructor notes, including individual student comments, may be saved automatically for future student review.

Clearly there is great interest in using this technology to enhance learning, but the current body of knowledge includes only a limited amount of direct measures of student success in achieving learning outcomes. For example, Hrepic, et.al[11] provided some direct measures in their work in physics courses. However, there is little, if any, information available on engineering courses. Instead, researchers typically use indirect measures for assessment, usually end-of-course surveys, which still do not lead to a clear understanding of the impact that technology has on student achievement of learning outcomes.

One of the authors of this work used the software Dyknow with tablet PCs for few semesters and in many classes, before doing the present research. All the surveys conducted in these classes reflected that most students were very satisfied with the use of tablet PCs and Dyknow. However, the fundamental question still existed. Could the students using the new technology obtain better grades at the end of a class than student in the traditional lecture format? The goal of this work is to answer this question by comparing final exam scores of two selected groups of students in the engineering class of Thermodynamics. These experiments were conducted during three semesters of the 2008 and 2009 calendar years, under a *2008 HP Technology for Teaching* grant. One section each semester of Thermodynamics was taught using HP tablet computers and the Dyknow software.

Research Methodology

Each student was provided an HP tablet computer for his or her personal use throughout the semester. These HP tablets were configured to permit the use of a wireless network, of which several are available on campus. The *2008 HP Technology for Teaching* grant included hardware for a dedicated wireless network for the Thermodynamics class. The students connected their tablet computers to the wireless network before class began. This arrangement proved wholly reliable.

For conducting the class, the educational software DyKnow was used. The DyKnow Vision package is a platform for delivering course content and interacting with students during class. DyKnow Monitor provided control over the students' computer activities during the class session. Importantly, as long as the student was connected to the DyKnow session, other programs (such as a web browser) were not available. In this way, distractions were reduced

Using the DyKnow software, lecture materials were displayed on a screen at the front of the room, as well as on each student's PC. Lecture materials were annotatable by the instructor, as well as the students, and subsequently saved by the respective student. However, the need for taking notes was thus greatly reduced using the present method. To promote active learning many activities were used during lectures. For example, words, phrases and equations were left out in the notes presented using the DyKnow software. Care was taken to include the missing material in the lecture, and to give students time to fill in the blank on their tablet screens. This helped students keep their focus on the lecture and course material.

A more involving substitution for note taking incorporated short problems the students worked in class and submitted electronically. These problems were usually designed to take 5–15 minutes of the class period. Students could anticipate needing to be prepared for class so they could work these problems. A topic was presented in class and at least one example worked through. During the next class period, the students were asked to work a problem over the same material. Students were permitted to refer to anything stored within DyKnow, as well as their texts and a handout providing equations, constants, and conversion factors. Property data were found in tables in the appendices of the text.

These in-class problems were corrected by the instructor, appropriate comments made, and a score given in most cases. In a few instances, insufficient time was available for the students to finish a problem, so these were corrected and commented, but not scored. The students usually did not know the problem would not be graded until the time for the problem was nearly depleted.

So, although the students could take notes and mark up the DyKnow frames as much as they desired, the majority of the usual note taking in a conventional class was replaced by in-class exercises where students could display their understanding of the material.

The goal in this experimental class structure was to compare the students' learning in this structure compared to a conventional lecture structure using Power Point slides or a white board. Therefore, some gage for measuring the success (or lack thereof) was required.

During the fall semesters of 2008, students were divided in two parallel courses according to their overall Grade Point Averages (GPA). To obtain equivalent groups of students, all students were divided in pairs with similar GPAs. One student of each pair was assigned to one class and the other to the other class. Both classes were taught by the same instructor using the same text and assigned the same homework and exams. One class was taught using Power Point slides and handouts, and the other using tablet PCs and the DyKnow software.

As there was only a single section of Thermodynamics during the spring semester 2009, the students' performance during this semester had to be compared to that of previous semesters. It would not have been expedient to give the same exams during the spring semester, 2009 as had been given in a prior semester. The only exam not returned to students in those previous semesters was the final exam. This exam was chosen to compare the performance of the spring semester 2009 students to those of previous semesters, who had been taught using a conventional approach.

During the fall 2009 semester, two sections of Thermodynamics were taught again. One section was structured around the DyKnow software, whereas the other was taught conventionally using a white board with the students taking notes. The same final exam was administered to these two sections as had been administered to the spring semester 2009 group and some of the previously, conventionally taught sections.

The seven sections from five semesters are summarized in Table 1.

Table 1. Thermodynamics sections used for this analysis.

	Number of Students:		
Semester	**Completed Course**	**Included in Comparison**	**DyKnow?**
Fall 2007	14	-	No
Spring 2008	12	-	No
Fall 2008	19	10	No
Fall 2008	14	10	Yes
Spring 2009	12	9	Yes
Fall 2009	8	-	No
Fall 2009	7	5	Yes

Results of the Study

The results of the first study, during the fall semester of 2008, are shown in **Table 2**. The group using tablet PCs and Dyknow will be referred as **F08D** and the group in the traditional setting or control group as **F08C**. The sample mean and standard deviation of the final grade of the F08D students were 74.9 and 10.52 respectively. The mean and standard deviation of the F08C student in the control group were 75.9 and 10.02. The GPA columns correspond to the overall grade point averages of the students before the fall 2008 semester. Since these students were selected by pairs with similar GPAs, the mean GPA and standard deviations are very close for both groups.

Table 2. Final grades of both groups at the end of Fall 2008

	(**F08D**) With Dyknow		(**F08C**) Traditional	
	GPA	**Final Grade**	**GPA**	**Final Grade**
1	4	90.9	3.986	90.5
2	3.972	88.1	3.955	65.8
3	3.844	79.1	3.908	85.5
4	3.766	70.1	3.657	67.5
5	3.765	83.1	3.508	80.1
6	3.534	69.9	3.281	75.4
7	3.081	61.3	3.194	77.9
8	2.889	74.3	2.983	59.8
9	2.588	73.1	2.62	70.3
10	2.431	59.1	2.488	86.4
Mean	**3.387**	**74.9**	**3.358**	**75.9**
Std.Dev.	**0.59**	**10.52**	**0.54**	**10.02**

Although the mean of the final grades of the F08C group is 75.9 and the mean of the F08D group is 74.9 we cannot conclude that the F08C group did better than the other. This is because these means are the means of samples and not of their populations. In the other hand, it is possible to demonstrate that it is very plausible that the mean of the population of the F08D group is bigger than the mean of the population of the F08C group. To demonstrate this conclusion the small-sample hypothesis test for the difference between two means was used.
Let μ_D represent that the mean of the population of F08D students, μ_C the mean of the population of F08C students, X_D represent that the mean of the sample of F08D students, and X_C the mean of the sample of F08C students. In our case $X_D = 74.9$ and $X_C = 75.9$.

Assuming null and alternate hypotheses to be
$H_0 :\ \mu_C - \mu_D \leq 0$ (equivalent to $\mu_T \leq \mu_D$),
and $H_1 : \mu_C - \mu_D > 0$ (equivalent to $\mu_T > \mu_D$)
The probability (or P-value) that $X_C - X_D = (75.9 – 74.9)$ when $\mu_C - \mu_D \leq 0$ is 0.415. This large value of P implies that $\mu_D \geq \mu_T$ is very plausible even though $X_D < X_C$. Then, we cannot conclude that either group performed better than the other. This result is a direct consequence of a small difference between the means X_C and X_D and big values in standard deviations.

For the two following semesters of spring and fall of 2009, the various groups used for comparison require different references for clarity. The following terminology is used in the remainder of this report:

F09D – The portion of the fall 2009 section used in this comparison. Five (5) students. DyKnow was used in the classroom.

F09C – The control group (conventionally taught) used for comparison to **F09D**. Five (5) students. Note that not all the students in this group took Thermodynamics during the fall semester 2009.

S09D – The single spring 2009 section. Nine (9) students. DyKnow was used for teaching in this class.

S09C – The control group used for comparison to **S09D**. Nine (9) students. Note that none of the students in this group took Thermodynamics during the spring semester 2009.

Control – The entire set of conventionally taught students who took the common final exam. Thirty four (34) students.

All – The entire set of students who took the common final exam – those taught with DyKnow and those taught conventionally. Fifty three (53) students.

The data were reduced and are presented in Table 3. The estimated range of the population mean for the final exam is expressed in this table by $\mu_{\min}$ and $\mu_{\max}$ where $\mu_{\min} \leq \mu \leq \mu_{\max}$ and μ is the mean of the population. Due to the small size of the groups, and due to the relatively large standard deviation of the final exam scores for the control groups, the estimated range of the population means for each control group is large.

The mean final exam score for each of **F09D** and **S09D** falls within the estimated range of population mean of all the control groups.

The mean final exam score for **S09D** was the same as the mean final exam score for **S09C** with 91.10% confidence. Note that the DyKnow group's mean final exam score was greater than the control group's. The mean final exam score for **F09D** was the same as that for **F09C** with 68.66% confidence. In this case, the DyKnow group's mean final exam score was notably lower than the control group's.

Table 3. Final grades of both groups at the end of spring and fall of 2009

	No. of	GPA		Final			
Group	**Samples**	**Mean**	**St. Dev**	**Mean**	**St. Dev**	$\mu_{\min}$	$\mu_{\max}$
F09D	5	3.000	0.479	52.00	19.51	—	—
S09D	9	3.353	0.536	50.78	16.72	—	—
F09C	5	2.989	0.507	58.60	15.58	39.25	77.95
S09C	9	3.344	0.538	49.56	10.60	41.41	57.70
Control	34	3.390	0.536	55.12	16.04	49.52	87.76
All	53	3.271	0.582	53.53	16.82	48.89	58.16

Conclusions and Comments

Results from all three semesters were very similar. Students using tablet PCs and the DyKnow system did not perform better than the students in the regular classroom.

During the fall of 2008 only ten students for the test group F08D and the control group F08C were selected. As shown above, both groups have almost identical final grades. Initially, however, all 14 students who finished the course with tablets were selected. In this case the final grades of the traditional group were significantly higher than the Dyknow group. But when four students from other than mechanical engineering were eliminated, the results were closer to each other. This seems to indicate that there are other factors that have more significant effect in the final grade than the utilization of tablets. A student taking this course as an elective course may not have the same motivation or background knowledge as a student taking this course as a required course, and as consequence two students with similar GPAs may have different final grades with or without tablets.

The DyKnow group, **S09D**, exhibited a mean GPA similar to that of the overall set of students, represented by **Control** and **All**. **S09D** included a number of higher performing students, as indicated by their individual GPAs. **F09D**, on the other hand, included essentially no higher performing students. As educators have learned, higher performing students tend to excel in a wide variety of settings. “Improvements” in teaching methods are nearly always successful to this category of student. It may be, the reason for the more favorable results for the **S09D** group compared to the **F09D** group is that the higher performing students carried the rest of the class. Arguably, however, it is not the higher performing student for which we seek improvements in pedagogy. The **F09D** results indicate lower performing students learn less well in a computer oriented setting than in a conventional white board lecture. However, the small sample set does not allow us a conclusive analysis of that aspect.

Clearly the student using tablet PCs were more satisfied than students in the traditional lecture format, but at end, the final grades do not show improvement in student learning. This is because there many more components in the learning process than the lecture alone. To improve learning we need to consider all the other important factors that affect learning such as motivation, goals, background knowledge, and time management.

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