WEB MODULES: NEW TOYS FOR ENGINEERING STUDENTS TO LEARN WITH

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Abstract

How far do we integrate technology, if at all, into our teaching? Instructors in engineering classrooms have traditionally used the chalkboard as the main medium to communicate engineering concepts to their students. The current movement within academia is to move more of the traditionally taught classes to an online learning environment. These two pedagogies can be thought of as the bookends of our current spectrum in education. Both techniques are appealing in their different application aspects, but they also have their own unique set of drawbacks. Instead of choosing one method over the other, the authors believe a hybrid pairing of the two pedagogies will be best suited to meet the educational needs of engineering students. To this end, the authors conducted a mixed methods research study, at a major research institution, wherein a web module was used to compliment a specific engineering concept taught in a traditional, undergraduate geotechnical engineering course. The main purpose of the study looked at how the web module affected student learning as well as their motivation for using or not using the web module. The qualitative instruments of the study included an anonymous online survey in addition to interviews with students as well as the instructor. The quantitative instruments involved a pre- and post-test and a homework assignment. This paper reports how both the students' and instructor's ideas about incorporating technology into the class were positively impacted by participating in the study. The results from the research indicate the students who used the web module showed more proficiency with the engineering concept then those students who did not use the web module.

Introduction

Engineers are known for pushing the envelope of innovation with their cutting edge ideas. In ancient times, when all people had to use for building materials were mud and straw, they tried to reach the sky by building the tower of Babel. Today, in their pursuit of building the tallest buildings, engineers are quite literally scraping the sky with the Sears and Petronas Towers. However, as these buildings stand as a testament to engineering accomplishments, so does the Tower of Pisa lean as a continual reminder that the tools are only as good as the engineer who uses them.

Traditionally, the chalkboard was the main tool engineering instructors used to communicate concepts to their students in the classroom. This lecture-style pedagogy fits well with the philosophy that the instructor was the expert imparting knowledge to the student. Even with the attrition of women and minorities in most engineering programs, this is still the preferred method of teaching[1]. The current movement within academia is to push more and more traditionally taught classes to an online environment. The main reason for this movement seems to be cost;

more students can be reached per instructor with distance learning and online courses than in a typical classroom setting[2]. The online environment also helps elevate the growing strain of dwindling classroom space on college campuses. To combat these and other educational problems, engineering colleges are turning in part toward technology for the answer. This brings up an important question. Is technology driving engineering education?

Both techniques are appealing in their different application aspects, but they also have their own unique set of drawbacks. Instead of choosing one method over the other, the authors believe a hybrid pairing of the two pedagogies is best suited to meet the educational needs of engineering students. Technology as a teaching tool should be adaptable to the course content and the instructor's needs. To this end, the authors conducted a mixed method research study at a major Midwest research institution wherein a web module was used to complement a traditionally taught undergraduate engineering course. The purpose of the study was to determine how the web module affected student learning of a specific geotechnical engineering concept.

Design and Development

The web module used in the pilot study is the first of four web modules, named Civil Engineering Computer Instructed Learning (CECIL), being developed for a larger research study. The web module was designed and developed by one of the authors who has a Bachelor's and Master's degree in geotechnical engineering from a major research institution and is currently working toward a PhD in engineering education. Initially, HTML was used as the framework for the web modules in CECIL. However, the limitations of HTML as the base code for the CECIL web modules were encountered early on in the development phase. A better fit for the web modules was found in Macromedia Flash. Using Flash as the foundational code for CECIL allows the web modules to be dynamic, interactive, and adaptable to different content areas and specific instructor needs. Deciding to use Flash also allows the web modules to be used on any computer platform and the Internet[3].

Pilot Study

The pilot study for the web module was conducted in an undergraduate geotechnical engineering course. This setting was chosen due to one of the author's background in geotechnical engineering and his doctoral research emphasis in engineering education. The specific engineering course for the pilot study was selected because one of the authors and the professor have collaborated on other innovative teaching methods in engineering education. The professor actively consults on high profile engineering projects and is a world-renown geotechnical engineering researcher. Along with his professional accomplishments, the professor continually ranks in the "Unofficial Top Ten" best engineering instructors on campus as voted by the students.

Every fall semester, the professor teaches the second course in the geotechnical engineering curriculum. The specific content contained in the web module was adapted from a specific engineering concept covered in the textbook used for the introductory geotechnical engineering course[4]. This same engineering concept is taught as a review and introduction to the second course, which the professor covers at the beginning of the course.

On the first day of class the students were given a homework assignment dealing with the specific engineering concept covered in the web module. The professor briefly covered the engineering concept in class and included the URL for the web module on the homework and instructed students to use the web module for review or assistance with the homework. They were also given twenty minutes at the end of class to complete a pre-test covering the different aspects of the engineering concept and some related ideas. A week later after the students turned in the homework assignment, they were given the same test, as a post-test, to be completed in the same twenty minute time period. The post-test had attached to it a short questionnaire used to gauge the depth of involvement of the student during the study. Approximately eight weeks into the semester the professor gave the first exam. One of the questions on the exam specifically addressed the engineering concept from the web module. The reason for this was to help the authors judge the long-term impact of the web module on student learning. Between the homework assignment and the first exam, all the students in the course were given the opportunity to fill out an anonymous online survey about their experience during the study as well as the design of the web module. There were six forty-five minute interviews conducted with three male and three female students on a voluntary basis. Informal interviews were also conducted with the professor throughout the semester to gauge the impact the research study had on his teaching and views of technology in the classroom.

Findings and Results

During the semester the study was conducted, the course had a total of thirty students with nine being female and twenty-one being male. One of the aspects the authors wanted to look at for the pilot study was the participation of the students, so no control group was assigned at the beginning of this study. After all the data was collected, the students were segmented evenly into three groups based on voluntary participation in the project. The first group of students used the web module as review and assistance with the completion of their first homework assignment. The second group of students accessed the web module, but only looked at and never used it for review or completing their homework assignment. The third group of students neither looked at nor used the web module during the study. The authors planned on using this third group as a "control group by choice" because the students decided not to participate in the web module part of the study. The data collected during the pilot study is shown below in Table 1. Descriptive statistics (mean and standard deviation) will be used in this paper to analyze the data from the research study. This is due to the fact the nature of the research is a pilot study with a small sample size (n = 30). A more detailed statistical analysis will be conducted in the future.

Group 3 can be used as a baseline for comparison across groups, because they did not have any contact or interaction with the web module. The scores from this group were used as a comparison group in analyzing the impact the web module had on student learning. However, when analyzing the pre- and post-tests scores for the groups, the authors noticed an interesting result. The mean score on the pre-test for Group 3 was approximately five points higher than the other two groups but only one point higher on the post-test. All three groups learned from the web module, but Group 1 and 2 learned more and increased their test score by 20 points (Table 3). The authors believe the reason for this difference in test results falls with how the control group was formed. Students who already had a command of the engineering concept or thought they did elected to be part of the third group by not using the web module. The evidence for

better understanding the concepts is seen in the pre-test scores of Group 3 being approximately five points higher than the other two groups. However, the same level of understanding was not seen in the homework and exam problem of the students who thought they knew the material (Group 3). Further analysis and tables comparing the data are later in the paper. In examining the quantitative data from the students who voiced this thought in their interview showed that the students really did not understand the concept as well as they thought.

	Gender	Look	Use	Beneficial [5.0]	Homework 1 [10]	Exam 1		Pre – Test [100]	Post – Test [100]
						Problem 1 [18]	Exam 1 Final Score [100]		
Group 1	F	Y	Y	4.0	9.0	18	78.9	56	69
	F	Y	Y	3.0	9.5	17	92.1	58	82
	M	Y	Y	4.0	9.0	18	92.1	41	73
	M	Y	Y	4.0	10.0	14	73.7	56	74
	M	Y	Y	3.0	9.5	18	90.4	-	69
	M	Y	Y	5.0	9.5	10	76.3	59	77
	M	Y	Y	4.0	9.5	17	91.2	64	92
	M	Y	Y	5.0	10.0	17	85.1	50	73
	M	Y	Y	3.0	9.0	18	100.0	-	63
	M	Y	Y	4.0	10.0	18	94.7	71	88
Group 2	F	Y	N	-	10.0	18	88.6	58	79
	F	Y	N	3.5	8.0	13	85.1	45	75
	F	Y	N	3.0	9.0	15	67.5	-	80
	F	Y	N	4.0	9.0	18	85.1	57	61
	F	Y	N	2.0	9.0	18	88.6	64	79
	M	Y	N	4.0	9.5	18	97.3	62	79
	M	Y	N	3.0	9.0	18	93.9	59	87
	M	Y	N	4.0	9.5	18	100.0	52	75
	M	Y	N	4.0	10.0	13	71.9	40	66
Group 3	F	N	N	-	10.0	15	86.0	54	73
	F	N	N	-	10.0	13	73.7	72	87
	M	N	N	-	9.0	17	95.6	58	76
	M	N	N	-	10.0	18	90.4	70	77
	M	N	N	-	-	-	-	70	80
	M	N	N	-	10.0	13	85.1	-	86
	M	N	N	-	7.0	18	97.4	56	77
	M	N	N	-	10.0	15	85.1	-	68
	M	N	N	-	10.0	17	89.5	64	89
	M	N	N	-	8.0	12	69.3	49	53
	M	N	N	-	7.0	18	66.7	63	-

TABLE 1: Data Collected

The initial data analysis by the authors focused on the homework assignment and exam problem. This was because the web module was directly related to the homework and students could use the web module to review for the exam. For the analysis the authors concentrated on

the means and left an in depth discussion of the standard deviations for another paper. The reason for this is because they are so similar and will only be used for comparative purposes. For the homework, Group 3 had a 9.1 average with Group 2 going up to 9.22 and Group 1 at the top with an average score of 9.50. For the problem on the exam, Group 3 had an average score of 15.60 with both Group 1 and 2 have average scores around 16.50. The positive effect of the web module on student learning is shown by the increasing trends in both the homework and exam problem averages (Table 2). This is not conclusive proof of the web modules impact due to the small sample size of the study. However, the trends in the data show the web module had some positive effect on student learning.

	Homework		Exam Problem	
	Mean	Std Dev	Mean	Std Dev
Group 1	9.50	0.41	16.50	2.59
Group 2	9.22	0.62	16.56	2.24
Group 3	9.10	1.29	15.60	2.32

TABLE 2: Homework and Exam Data

The authors used the pre-/post-test, along with the homework assignment and exam problem, to determine the effectiveness of the web module. Group 1, students who used the web module, had a mean score of 57, which was two points higher than Group 2, students who only looked at the web module. The standard deviations between the two groups were statistically similar. On the post-test scores the mean of both groups was 76 with Group 1 having a slightly higher standard deviation of 9.0 when compared to the 7.8 of Group 2. The data shows both Group 1 and 2 raised their mean scores by approximately 20 points from the pre-test to the post-test. Group 3 had an average score on the pre-test of 61 with a standard deviation of 8.2. On the post-test their average score was a 77 with an increase of the standard deviation to 10.6. Table 3 lays out the pre- and post-test scores from all three groups. Using Group 3 as a baseline where their scores increased approximately 10 points; it can be seen the web module had a positive impact on student learning by raising the scores of Group 1 and 2 an extra 10 points to coincide with Group 3.

	Pre - Test		Post - Test	
	Mean	Std Dev	Mean	Std Dev
Group 1	57	8.9	76	9.0
Group 2	55	8.4	76	7.8
Group 3	61	8.2	77	10.6

TABLE 3: Pre- / Post -Test Data

Figure 1 graphically shows the pre-test and post-test grade distribution for the entire class. It shows the shape of both curves is similar with a standard deviation of 8.8. Most notable is the

shift of mean post-test scores approximately 20 points higher. Due to the small size of the three groups the authors were unable to properly graph the test scores of the individual groups.

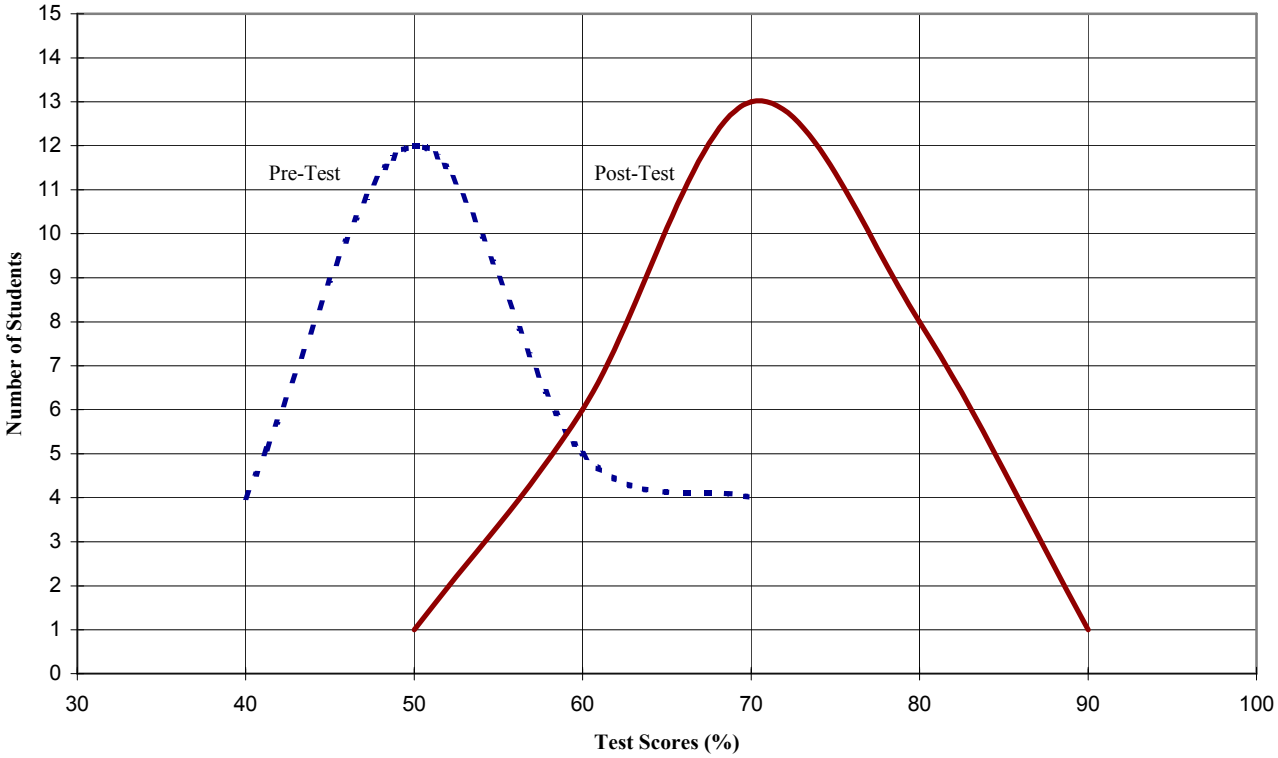

FIGURE 1

In the recent past, gender issues and the attrition of women have been issues within engineering education[5]. Even though these issues were not a focus of this study, the authors wanted to see if there were any differences in the impact the web module had between male and female students. The authors encountered some surprising findings during the analysis of the data. Before continuing, it should be pointed out again there were twenty-one male students and nine female students. The standard deviations between the two groups were always similar with the difference being explained by the discrepancy in cohort size with the rest of the analysis focusing on the means of the groups.

While only two women used the web module to help them with their homework, the mean homework scores between the two groups were both 9.28. Upon further investigation the authors found that the students work in groups and often help each other with homework problems, which most likely explains the similarity between the means. The means of the exam problem are not exactly like the homework problem, but are similar with the men's average score slightly higher over the women's with 16.25 to 16.11. The similarities between the means continue when looking at the pre- and post-test scores. On the pre-test each groups' average score was a 58. On the post-test their average scores increased to 76, with standard deviations of 7.7 for the women and 9.5 for the men on both tests. The authors were surprised there was no difference between the two groups found in the data, but encouraged to see both groups improve

their post-test average by 18 points over the pre-test. The correlation to the treatment's effectiveness is inclusive in this case because, while a majority of both groups looked at the web module, the exact extent this impacted their learning of the engineering concept was not determined in this study. In depth interviews with every student would be needed to better establish the web modules impact.

	Homework		Exam Problem		Pre - Test		Post - Test	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Female	9.28	0.67	16.11	2.15	58	9.3	76	9.6
Male	9.28	0.94	16.25	2.49	58	7.8	76	7.7

TABLE 4: Gender Data

In this pilot study, it was not only important for the authors to show the positive impact of the web module, but also to see how the students responded to using it in the course. To accomplish this, the students were solicited for voluntary interviews. The authors chose six students to represent the three different groups. All the students, regardless of web module use, were also asked to fill out an anonymous online survey. A more detailed qualitative analysis will be presented at the 2005 Illinois-Indiana Section Conference of ASEE later this year, with only a short synopsis in this paper[6]. There was a 90% response rate to the online survey, with a 50/50 breakdown of students who used the module to students who did not. Based on the surveys and interviews, the reasoning from students who did not use the web modules was because they saw the engineering concept as basic material they did not need to review. On the other hand, all the students who used or accessed the web module said they found it beneficial with comments like the following:

> "I think the content was beneficial because it was presented in a simple, yet complete manner."
>
> "Very helpful, although Holts and Kovacs is a good text, and the examples came directly out of the book, it is sometimes difficult to follow. The module was instrumental in my quickly learning and/or reviewing the material."
>
> "I thought the website presents the fundamentals of Geotechnical engineering in a clear and accessible manner. If I was looking for help in a particular area, I could easily navigate to that portion of the website."

Conclusions

Even though the authors could not find similar studies researching the impact of a web module in a traditionally taught engineering course, the studies they did find showed technology had a positive impact on student learning[7,8,9]. Combined with previous research studies, this research study supports the following hypothesis: A web module can be an effective learning tool for students when incorporated into a traditional lecture-style engineering course. The students who used the web module during the pilot study scored higher on the homework assignment and exam problem than those students who did not use the web module. Students

who looked at and/or used the web module increased their post-test scores by approximately 20 points. Groups 1 and 2 had a net increase of five points on their post-test scores over Group 3, students who never accessed the web module. When a gender comparison was done, no treatment effect was identified between males and females. This indicates the web module did not have any gender bias and suggests that it is an equal and effective learning tool regardless of student gender.

The pilot study showed the web module was beneficial for increasing students learning, but we believe that it might have had a greater impact and been more useful in the introductory course where the concept was first taught to the students. This belief was mirrored by the students in the interviews with statements like "I think this program would have really helped me when I was learning the phase diagram concepts because it shows you very clearly how to solve problems with the phase diagram" and "It would help to see the material in a different way. The presentation in [the introductory course] was a bit one sided an without lab info." A majority of the students, in interviews and the survey, thought the engineering concept covered by the web module was basic material they already knew and was just a review for them.

It should be reiterated that this was a pilot study and a work in progress for the authors. The initial web module was developed and an opportunity came available to conduct a pilot study on the feasibility of the web module. The data gathered from this pilot study will assist the authors in developing four other web modules, which will used in a longitudinal study in the introductory engineering course.

Recommendations

As a result of this study, we are reminded that we as engineering educators need to understand our own technological needs as well as the needs of our students. Technology should not be used in teaching just for the sake of using technology. It is important to understand which is the best educational tool to use for teaching a specific content. Using a web module to teach is not a "one tool fits all" situation. It is very important to align the materials covered in the web module with the content covered by the instructor in the course. Most importantly, no matter how well the web module is designed, the instructor has to buy into the idea of using a web module in their course and properly integrate into their curriculum.

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