Effectiveness of Student Learning—a Comparison between Online & Face-To-Face Formats

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Abstract

The effectiveness of delivery systems for engineering courses has been long debated. In this study, two modes of delivery systems were compared, an online system, and a conventional face-to-face system to two cohorts of undergraduate students. To reduce variability, both courses were instructed by the same instructor, using the same textbook, and accompanied the same instructional material. The face-to-face class (control group) met twice a week for 90 minutes each session. The instructional material for the online students (experimental group) was made available to students via a secure website in an asynchronous mode. In addition, an audio version of the lecture materials was embedded using an internet-software for the online version of the course. The grade point averages (GPAs) of both groups of students were compared to ensure that both groups are comparable. A uniform pre-test was administered to both groups to identify any significant prior knowledge about the subject matter between these two groups. Several hypotheses were tested to assess the overall effectiveness of the online course in comparison to the traditional in-class lectures. In addition, other factors such as gender, and class standing were compared and analyzed.

Introduction

An education delivery mode through the internet has created new and innovative opportunities to deliver education electronically (Summers et al, 2005). Recently, several institutions have started introducing online quizzes and exams to provide more flexibility for students enrolled in their programs (Bliuc et al, 2009). Popularity and cost effectiveness of web-based courses, combined with more interactive and user-friendly software systems have made online programs very attractive to both graduate and undergraduate students (Wang et al, 2007, Peterson et al, 2004, and Harrington et al, 2009). Many studies have compared online and traditional face-to-face classroom instruction (Summers et al, 2005; Bliuc et al, 2009; Wang et al, 2007; Peterson et al, 2004; Harrington et al, 2009; Young et al, 2006; Campbell et al, 2008; Cragg et al, 2008; Price et al, 2007; and Bentz et al, 2009). However, the results of the effectiveness of these methods have varied widely and created room for debate.

Summers et al (2005) have conducted such a study using an introductory statistics course, using both traditional face-to-face, and online distance education formats. Students' final grades and overall satisfaction with the course were both measured.

The results indicated no statistically significant difference in students' grades between these two methods, however, students enrolled in the online section were significantly less satisfied with the course (Summers et al, 2005). In a separate three part study, the traditional face-to-face tutoring was compared to computer-based mediated seminar and email (Price et al, 2007). The results from these studies reported worse experience for students receiving online compared to those receiving face-to-face tutoring. The primary goal of this paper is to understand the effectiveness of online versus traditional face-to-face classroom instruction for an engineering course.

Method

A popular and required undergraduate course for most engineering disciplines, Engineering Economy, was selected for a semester long study. Lecture materials and class notes were converted into a digital format using MS PowerPoint. In addition, the online audio lectures were recorded using Camtasia-Studio 6.0 to emulate a conventional classroom setting. Two sections of the course were separately offered under different sections to two selected cohorts of students. The first section (control group) was offered in a traditional face-to-face format and the lectures were conducted twice per week. Simultaneously, a second course (experimental group) was also offered and delivered using an online mode. The lectures were delivered online and students met the instructor once a month prior to each exam for review. To minimize experiment noise, the same instructor and a teaching assistant were assigned to both courses, and both student groups had access to course instructor and teaching assistant by email. In addition, a common course syllabus was provided to both groups with minor changes in details due to the nature of different lecture delivering modes. Homework assignments (worth 10% of the overall course grade), quizzes (worth 10% of the overall course grade), a term project (worth 20% of the overall course grade), and three exams including a final exam (worth 20% each of the overall course grade) contributed to the overall course final grade for a total of 100%. Individual grades from the two classes were compared in terms of the average of each of the assignments and grade components to determine the comparison between the two instruction methods. In order to eliminate the potential for cheating during quizzes and exams, both groups were asked to take all testing materials in person and in class, while being proctored by the instructor and multiple teaching assistants. Furthermore, preliminary analysis was also conducted to check if the two groups were homogenous starting GPA at the beginning of the course, level of education as a student, etc. The analysis included age, gender, grade level, overall GPA (before taking the class), and a pre- and post-test. Before data analysis was conducted, the grades from both groups were plotted utilizing Minitab software at 95% confidence level to show that both groups were normally distributed. Because the number of students in each group is not the same, a 2-tail unpaired independent sample *t*-test (type 3) was used to compare the two groups (comparing two different sample sizes of unequal sample variance). The following formulas indicate these measures:

H_o: $\mu_{F2F} = \mu_{online}$

H_1: $\mu_{F2F} \neq \mu_{online}$

Results

There were 38 students participating in the traditional face-to-face class, and 18 in the online class. Table 1 below shows the descriptive survey results obtained from the two classes by Gender.

Table 1: Number of Students by Gender

Gender	Face-To-Face (n)	Online (n)
Male	22	12
Female	11	3

Table 2 shows the descriptive survey results obtained from the two classes by Grade Level.

Table 2: Number of Students by Grade Level

Grade Level	Face-To-Face (n)	Online (n)
Sophomore	8	0
Junior	21	11
Senior	0	4

The results of the preliminary analysis (Table 3) shows the comparison between the two groups in terms of age, overall GPA (before taking the class), and the pre- and post-test, including the change between them (delta, Δ).

Table 3: Results of the Preliminary Analysis

	Face-To-Face		Online		p-value
	Mean	Std	Mean	Std	
GPA	3.06	0.41	3.13	0.39	0.5991
Age	25.42	7.59	23.6	5.39	0.3600
Pre	14.97	12.16	61.8	22.73	**0.0000011***
Post	68.18	16.32	59.62	21.97	0.2354
Δ	52.43	14.83	2.18	22.52	**0.0000169***

*denotes that these *p*-values are statistically significant at the 95% confidence level.

Table 4 below shows the comparison between the pre- and post-Tests for both groups.

Table 4: *p*-value for Comparing pre- and post-Tests for both groups

	Pre-Test		Post-Test		p-value
	Mean	Std	Mean	Std	
Face-To-Face	14.97	12.16	68.18	16.32	**3.09726×10-18***
Online	61.8	22.73	59.62	21.97	0.3828

*denotes that these *p*-values are statistically significant at the 95% confidence level.

The results of the performance comparison analysis (Table 5) shows the comparison between the two groups in terms of average overall homework score, overall average quizzes score, the results of Exam 1 scores, Exam 2 scores, the Project scores, the Final exam score, and the overall performance in class.

Table 5: Results of the Performance Comparison Analysis

	Face-To-Face		Online		p-value
	Mean	Std	Mean	Std	
Avg HWs	84.93	12.31	75.51	24.41	0.1571
Avg Quizzes	65.89	21.21	74.11	17.52	0.1844
Exam 1	86.68	11.38	83.6	10.88	0.3805
Exam 2	84.43	19.25	88.13	11.41	0.2942
Project	93.66	6.24	94	3.74	0.8124
Final Exam	64.08	12.15	66.1	13.37	0.6276
Overall Score	79.31	11.07	81.07	7.89	0.5301

Discussion

The analysis indicated that while there is no significant difference at any preliminary measure (in terms of overall GPA-before taking the class, and a post-test), it showed a strong statistically significant difference between the means of the two groups at the pre-test measure at a 95% confidence level. However, after finishing the class, the post-test indicated that both groups have ended at the same level of knowledge about the subject matter.

Also, the results suggest that there is a significant difference between the means of the pre- and post-tests for the face-to-face class, indicating that this group seemed to learn more compared to the experimental group. A comparison between the results of the pre- and post-tests were conducted, and the data show that the results of the post-tests were slightly lower than those of the pre-tests for students enrolled in the online class. However, their delta score indicates a non-significant difference between their scores at the pre- and post-tests. Plots of the course grades for the two groups utilizing Minitab software at 95% confidence level show that both samples are normally distributed.

A *t*-test was also used to test a null hypothesis stating that there is a statistically significant difference at the 95% confidence level of these two groups for the overall average homework score, overall average quiz score, Exam 1 score, Exam 2 score, the Project score, the Final exam score, and the overall performance in class. The analysis showed that there is no statistically significant difference between the two groups at any performance measures used in this study. Hence, the null hypothesis cannot be rejected. Furthermore, although no significant difference between the standard deviation of the scores was identified, the box plot showed less dispersion in the scores of the face-to-face compared to the online course. In addition, the means of final scores for male and female students within and between both groups were also compared to see if there is a statistically significant difference on gender. At the 95% confidence level, the results indicated no statistically significant differences between male and female students for both within each group and between the groups.

Conclusions and Recommendations

Selected two cohorts of engineering students were measured to test if there is any significant difference in the learning and delivery method for a popular engineering course. The results showed that at the 95% confidence level, there is no significant difference. However, the face-to-face class showed better improvement in terms of pre- to post-Tests than the online class. Furthermore, students from the two groups were verbally interviewed periodically by the instructor to ensure that both groups are receiving the required dose of learning. Both groups have always indicated that the materials have been delivered adequately. While online and distant learning methods can offer a certain degree of convenience to many students, our study shows that the traditional in-class lectures slightly outperformed online modes of delivery. This may explain why most students still prefer to take classes in class and would prefer interacting with the instructor in person.

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