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The Impact of Online Lecture Notes on Learning Outcomes of Beginning Thermodynamics Students

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Abstract

A study was undertaken to determine the impact of online lecture notes on learning outcomes of students in a web-assisted first engineering thermodynamics course taught in a traditional face-to-face classroom setting. In the control group lectures were presented using a classroom computer projector and chalkboard. In the test group the same material and approach were taken, but the instructor's lecture notes were made available online the day before each class. Students were encouraged to download and print out the notes and bring them to class to minimize time spent taking notes in class.

At the end of each semester, the same multiple-choice final examination was administered and student performances recorded. Although a difference in final exam grades was found between the two groups, with the group having lecture notes available online not performing as well, the difference was not statistically significant.

Statistical analyses were also performed among sub-groups in the overall study population. Students were stratified with respect to incoming grade-point-average, academic major, and semester hours completed. No statistically significant differences were found in any of the sub-groups examined. Finally, comparisons were made between the two groups on exam questions at two different levels within Bloom's taxonomy of the cognitive domain. Again, no statistically significant difference was found between the control and test groups.

Introduction

There is little doubt that the Internet and the vast collection of Internet-accessible information known as the World Wide Web have changed forever the way we gain information. While this is certainly true in our everyday lives, with nearly 70% of Americans now having access to the Web[1], it is becoming increasingly true in the educational sector as well.

According to a recent report[2] by the Sloan Consortium, nearly 3.2 million students in higher education were enrolled in online courses in fall 2005 compared to 2.3 million in fall 2004. The

report also found that over 80% of these students were undergraduates with slightly over 50% studying at two-year Associates institutions.

Online instruction takes on a number of forms, ranging from web-assisted courses that offer some course material online while still meeting face-to-face regularly to fully online courses where no face-to-face meetings occur.

It is interesting to note that engineering, steeped in high technology and well versed in its applications, has seemingly been one of least interested members of the higher education community to embrace online education, especially at the undergraduate level. A recent study by Ibrahim and Morsi[3] found that of the 126 educational institutions in the U.S. that offer an Electrical and Computer Engineering degree, only 30% offer online engineering degrees at all and over 90% of the degrees offered are at the graduate level. Only one institution among the 126 examined offers an online undergraduate engineering degree.

Background

In a study by McSporran[4], the posting of online lecture notes was ranked third in importance with regard to having the highest value by students in a graduate computing program in New Zealand, preceded only by online posting of assignments and announcements. An earlier study by Frey et al.[5] had found that the posting on lecture notes online ranked in the top five strategies perceived as having value by social work students in the U.S. Likewise, Leung and Ivy[6] reported that online lecture notes ranked second in importance among student perceptions of eight online strategies employed to enhance learning.

Given these positive student perceptions of the use of online lecture notes, the current study was begun in Fall 2004 to determine the impact of online lecture notes on learning outcomes of students in a first engineering thermodynamics course taught in the Herff College of Engineering at The University of Memphis. Although delivered in a traditional face-to-face classroom setting, the course was "web-assisted" since a number of course materials were provided online.

Methods

The introductory thermodynamics course used in the study is taken by most engineering majors in the college. It covers the First and Second Laws along with a number of other topics usually covered in such a course. Traditionally this course has been taught using the familiar chalk and blackboard approach. A few years ago, however, the course moved from the traditional approach to one of being web-assisted, meaning that a number of course materials were made available to students online. These materials included the course syllabus, assignments, homework solutions, class grades, and links to websites related to thermodynamics.

This web-assisted approach migrated to the WebCT platform in fall 2004 where it remained through the fall of 2006. During that time a series of 34 sets of lecture notes were prepared for use in the classroom. Originally in HTML format, these later were converted to the Adobe PDF format, but the content remained unchanged.

In both the control group and test group the materials were presented using the standard lecture and chalkboard method, supplemented by a classroom computer projector that displayed the lecture notes. In addition, active learning was promoted throughout the semester by having the students form small teams during class to solve a problem directly related to the lecture material. The same instructor taught the course throughout the study.

In the test group the instructor's full lecture notes were made available online the day before each class whereas no notes were made available online to the control group. The lecture notes contained text, graphics, and hypertext links to pertinent materials on the Web. The latter included multi-media sites that provided animations or simulations related to the lecture topic to help students understand the concepts being introduced. Students in the test group were reminded and encouraged throughout the semester to download and print out the notes and bring them to class to minimize time spent taking notes in class and to maximize the time spent listening to the lecture and participating in classroom discussions.

A total of 101 students were participants in the study, and informed consent forms were obtained. Table 1 summarizes some of the pertinent characteristics of the two groups. A Students' t-test was performed on the data, and the resulting p-values indicate that the two groups were statistically the same with respect to these characteristics.

Table 1. Characteristics of the Control and Test Groups Used in the Study.

	Control Group (Mean ± SD)	Test Group (Mean ± SD)	Difference	p-value
Total Number	46	55		
Arriving GPA	2.97 ± 0.47	2.93 ± 0.45	0.04	0.608*
Arriving Semester Hours Completed	96.1 ± 35.4	91.5 ± 41.5	4.6	0.528*

* Not a statistically significant difference

At the end of each semester, the same multiple-choice final examination was administered and student performances recorded. This exam was comprehensive and consisted of both "information-recall" questions on a particular topic and multiple-part questions requiring a more involved analysis, similar to what students encounter on the Fundamentals of Engineering examination. Because the exam was multiple-choice, no partial credit was assigned to incorrect answers, thus eliminating any grading inconsistencies.

Results

Surveys were undertaken to determine the extent to which students were downloading and using the online lecture notes. A series of five questions were posed, and responses were indicated using a 5-level Likert scale that ranged from Strongly Agree to Strongly Disagree. Table 2 summarizes the results obtained in sections where the online lecture notes were made available. Although 80% of the students printed out the notes before class, only 41% actually looked over the notes before attending class. While daily quizzes on the material covered in each day's notes

would most likely have increased the number of students reviewing the online notes, this approach was not used because detailed daily reading assignments were not made in the control group. Thus, a second variable would have been introduced.

However, it is interesting to note that all of the students claimed to use the notes after class, and virtually all felt that having online noted helped them focus on material discussed in class. Finally, over 70% of the students felt that the online notes helped them to learn the material better. This latter perception agrees with those cited in the aforementioned studies by McSporran[4], Frey[5], and Leung and Ivy[6].

Table 2. Survey results for students in sections where online notes were made available.

	Disagree or Strongly Disagree	Neutral	Agree or Strongly Agree
I almost always print out the lecture notes before class.	12%	8%	80%
I almost always review the online lecture notes before class.	18%	41%	41%
Having online lecture notes helps me to focus better on what is being discussed in class.	0%	4%	96%
I frequently use the online lecture notes after class to review the material discussed in class.	0%	0%	100%
I learn the material better by having online lecture notes available before class.	4%	24%	72%

Student performances on the common final examination were recorded along with the students' final overall averages in the course. Table 3 summarizes these results. Although a difference in final exam grades was found between the two groups, with the group having lecture notes available online not performing as well, the difference was not found to be statistically significant ($p = 0.396$).

Table 3. Overall Student Performance Comparison.

	Control Group (Mean ± SD)	Test Group (Mean ± SD)	Difference	p-value
Number	46	55		
Final Exam Grade	73.8 ± 17.0	70.8 ± 18.1	3.0	0.396*
Overall Course Average	75.9 ± 10.6	73.7 ± 12.4	2.2	0.339 *

* not statistically significant

Likewise, the results in Table 3 show no statistically significant difference in the overall course averages of the two groups, although the control group's average was again slightly higher than that of the test group.

Two-factor Analysis of Variance (ANOVA) with replication analyses were performed among sub-groups in the overall study population. Students were stratified with respect to incoming

grade-point-average, semester hours completed, and academic major. The results of these comparisons are shown in Tables 4-6.

Table 4 shows that students with arriving GPAs above 3.0 performed better (in a statistically significant way) on the final exam than those arriving with GPAs below 3.0, a result that was not at all surprising. However, the ANOVA results reveal no significant difference (at the $p = 0.05$ level) between the control and test sub-groups, and no interaction effect between the factors was found.

Table 4. Two-factor ANOVA of Sub-group Data Based on Arriving GPA

		Control Sub-Group (Mean ± SD)	**Test** Sub-Group (Mean ± SD)	**2x2 ANOVA Results**
GPA > 3.0	Number	21	25	Effect of Incoming GPA $p = 0.007$**
	Final Exam Grade	79.5 ± 16.5	75.4 ± 15.6	
GPA < 3.0	Number	25	30	
	Final Exam Grade	69.0 ± 16.2	67.0 ± 19.4	
2x2 ANOVA Results		Effect of Online Notes $p = 0.377$*		Interaction of Notes x GPA $p = 0.761$*

*not significant
** significant at $p<0.05$ level

Table 5 shows there were also no significant differences between the control and test sub-groups when the sub-grouping was done with respect to the number of semester hours completed before attempting the thermodynamics class. Likewise, the number of semester hours completed before taking the course was not found to be a significant factor. Finally, no interaction between the two factors was found either.

Table 5. Two-factor ANOVA of Sub-group Data Based on Semester Hours Completed.

		Control Sub-Group (Mean ± SD)	Test Sub-Group (Mean ± SD)	**2x2 ANOVA Results**
Hrs > 85	Number	25	28	Effect of Hrs completed $p = 0.623$*
	Final Exam Grade	76.2 ± 17.6	70.0 ± 18.0	
Hrs < 85	Number	21	27	
	Final Exam Grade	71.0 ± 16.2	71.7 ± 18.6	
2x2 ANOVA Results		Effect of Online Notes $p = 0.440$*		Interaction of Notes x Hrs $p = 0.333$*

*not significant

When the students were grouped according to academic majors, the ANOVA results once again indicate no significant differences, as shown in Table 6.

Table 6. Comparison of Students based on Academic Major

		Control Sub-Group (Mean ± SD)	Test Sub-Group (Mean ± SD)	**2x2 ANOVA Results**
M.E. Majors	Number	16	27	Effect of Major p = 0.117*
	Final Exam Grade	66.3 ± 16.6	70.9 ± 19.1	
Non-M.E. Majors	Number	30	28	
	Final Exam Grade	77.8 ± 16.1	70.7 ± 17.4	
2x2 ANOVA Results		Effect of Online Notes p = 0.727*		Interaction of Notes x Major p = 0.104*

*not statistically significant

As mentioned above, on the common final exam, some of the questions involved only the recall of information and would be at the "knowledge-level" of Bloom's Taxonomy[7]. Other questions, however, were much more analytical in nature and involved a number of calculations. These would presumably be classified on Bloom's scale at the "analysis level" within the cognitive domain. The performance of the students on these two types of questions are summarized in Table 7. The ANOVA results indicate no statistically significant effect of providing the lecture notes online but a strongly significant effect of the cognitive level of the exam questions with students performing much better on the knowledge-level questions than on the analytical-level questions. Once again, this was not a surprising result. The interaction of the two factors produces an effect that is not quite statistically significant (p = 0.0767).

Table 7. Comparison of Students based on Cognitive Level of Exam Question

	Control Sub-Group (Mean ± SD) n = 46	Test Sub-Group (Mean ± SD) n = 55	**2x2 ANOVA Results**
% Correct on 3 Knowledge Level Questions on Final Exam	81.9 ± 21.9	87.3 ± 17.6	Effect of Cognitive Level p = 1.276×10^{-7}**
% Correct on 5 Analytical Level Questions on Final Exam	69.1 ± 24.5	62.2 ± 31.4	
2x2 ANOVA Results	Effect of Online Notes p = 0.828*		Interaction of Notes x Cognitive Level p = 0.0767*

*not statistically significant
** statistically significant

Discussion

The original hypothesis for the study was that online lecture notes would enhance the learning outcomes of the students since they would spend less time in class taking notes and more time listening to the lectures of the instructor and classroom discussions of the material. However, as can be seen, this hypothesis was clearly not supported by the results obtained. Both similar and dissimilar findings have been reported in recent studies.

Silcox[8] compared the performance of students enrolled in fully online and conventional sections of an engineering thermodynamics course and found no difference in scores earned on identical final exams nor in grades earned in subsequent thermodynamics classes. Trippe[9] likewise found no statistically significant difference in the performance of students in a fully asynchronous distance learning graduate telecommunications course and the performance of students in a blended environment that met face-to-face only once a week.

However, Wellington et al.[10] did find a statistically significant difference in exam grades earned by students in a Non-Internet Enhanced (NIE) section of a marketing course compared to students enrolled in a similar Internet Enhanced (IE) section, with the NIE students performing slightly better. Rutz[11], on the other hand, recently reported that students in web-assisted sections of a beginning mechanics class earned statistically significantly better course grades than students in sections of the same course taught in a traditional manner.

While it is true that online lecture notes relieves students of the burden of taking notes while trying to listen to the classroom lecture and discussion, students receiving prepared notes do miss out on the learning that occurs when one actually writes down information. Also, by having lecture notes available online, students may feel less compelled to attend class. Although class attendance was not a problem in the current study, Wellington et al.[10] found a significant attendance reduction among students in their internet enhanced classes.

The results become less surprising when learning styles of engineering students are taken into account. A number of past studies[12-13] have shown that engineering students are visual rather than verbal learners, meaning they learn better from visual images rather than words they hear or read. In a multi-campus study involving over 2500 undergraduate engineering students, Felder and Brent[12] found that 82% of engineering students are visual learners and only 18% are verbal learners. Studies conducted among engineering students at the University of Memphis, where the current study was undertaken, have revealed similar characteristics[14]. Since the online lectures made available to the study group in the current study provided the information in the same form as the in-class lectures, it should perhaps come as no surprise that the learning was similar in the two groups.

Conclusion

Although students perceive that having lecture notes available online enhances their learning, the current study provided no evidence to support this perception. Similar studies in the recent past have reached this same conclusion, but a few have found support for the students' perception. However, the fact that students perceive that online notes help their learning may indeed make

their educational experience more satisfying. Because of these mixed findings, further work is obviously needed to determine whether the perception is justified.

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