2006-1151: A COMPARATIVE ANALYSIS OF ONLINE AND IN-CLASS VERSIONS OF ENGINEERING CULTURES

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A Comparative Analysis of Online and In-class Versions of Engineering Cultures

Abstract:

At many institutions, online courses are becoming increasingly available. Yet, very little research has been completed on the effectiveness of online courses as compared to in class versions. "Online" is defined here to be a course in which all instructional and course materials are available via internet. At Virginia Polytechnic Institute and the Colorado School of Mines a course titled, *Engineering Cultures,* has been offered both online and in class. Based on the current Accreditation Board for Engineering and Technology criteria, all engineering students should have some understanding of global issues, suggesting the importance of courses such as *Engineering Cultures*. If such a course can be delivered online, access can be provided to a broad range of engineering students. Online seems to be an excellent method to provide broad access to educational material, but is it as effective as in class versions of the same course? As part of this study, a multiple choice pretest and a posttest were administered to a treatment and control group. The treatment group completed the online version of the course and the control group completed the in class version of the course. Both groups also completed a survey at the end of the course. The results of this analysis were surprising: the treatment group displayed greater increases from pre to post test than did the control group. In other words, the online students displayed a greater increase in knowledge as measured by the test than did the in class students.

I. Introduction:

An online course is defined here to be a course in which all the instructional and course materials are available via internet. Often these sites are password protected and access is provided only to enrolled students. Materials can include papers, assigned readings, pre-recorded lectures, notes, exams and quizzes. Typically, software programs, such as Blackboard, allow the instructor to control when students view material and what material they view. This allows teachers to further determine when an exam is administered and the amount of time permitted to complete the exam. With the exception of face-to-face interaction, online has all of the elements of regular instruction.

Online learning, however, has yet to receive a great deal of research attention. Many questions remain concerning the appropriateness of online learning. For example, how effective is on-line learning? Is it possible to gain as much knowledge through computer interaction as with a professor in the room interacting with students? How does student learning differ in online or in class versions of a course?

A course titled *Engineering Cultures* was designed and first implemented by Drs. Gary Downey, Virginia Polytechnic Institute (VP), and Juan Lucena, Colorado School of Mines (CSM). *Engineering Cultures* is designed to teach future engineers how the culture of engineering differs across various countries. For example, there are large differences among the expectations and roles of engineers in France, United Kingdom, Germany, and the United States. This impacts the manner in which engineers interact and solve problems. Although these countries share many underlying similarities, the role and expectations of engineers are very different; these roles have evolved through the histories of the countries in which the engineers reside.[1]

As countries become more intertwined, engineers are much more likely to collaborate across national boarders. To maximize the benefit of collaboration, engineers need to be able to understand and communicate with each other[1]. The increase in international collaboration supports the importance of offering courses such as *Engineering Cultures*. Furthermore, according to the criteria set forth by the Accreditation Board for Engineering and Technology (ABET)[2], all engineers need to be aware of global issues. A detailed description of *Engineering Cultures* can be found in Downey et al[3].

Engineering Cultures is currently being taught at VT and CSM. The section at CSM is taught by a member of the faculty; while the sections at VT are taught by several teaching assistants under the direction of a faculty member. VT offers the course in both online and in class versions. The purpose of this paper is to compare the effectiveness, in terms of student learning, of the online version of the course to the in class version of the course.

II. Research Questions:

This investigation seeks to examine whether students learned more in the online version or the in class version of the *Engineering Cultures* course. The research questions are as follows:

1. Is there a measurable difference in learning between the students who completed the online version of the Engineering Cultures course compared with the students who completed the in class version?
2. Do the students who complete the online version of the course feel that they have gained as much knowledge as their classroom counterparts?

III. Methods:

The following section includes an overview of the methodology used in this investigation. This includes a description of the subjects, instruments, and analysis techniques. All appropriate human subject procedures were followed throughout this investigation.

A. Subjects:

The subjects in this study are students enrolled in either the online version or in class version of *Engineering Cultures*. All online versions were taught at VT while in class versions were taught at VT and CSM. At VT, *Engineering Cultures* is a sophomore level course[4]; at CSM, this course is offered at the junior level[5].

B. Instruments:

For the purpose of measuring changes in students' knowledge from beginning to end of the course, a pre and post content assessment was developed. This twenty-five question multiple choice assessment was administered the first and last week of the course. Both the pre and post content assessments shared identical questions and have been designed to measure student understanding of the course content[6, 7]. This instrument is displayed in the Appendix.

At the conclusion of the course, students also completed a self-report survey. The question that was of interest in this investigation was, “I believe I learned more in the online version of the course than I would have learned in a classroom version” and used a Likert scale format with four options, Strongly Agree, Agree, Disagree, and Strongly Disagree.

C. Limitations:

The limitations of this study result from the use of a quasi-experimental design[8]. Since the students select to enroll in either the online or in class version of the class, random assignment was not possible. This is recognized as a common and unavoidable limitation in research that investigates online and in class versions of courses[9].

D. Analysis:

To statistically compare students’ performances in the online and in class versions of the course, a two-sample t-test was used to examine pretest, posttest and difference scores. Difference scores are defined to be the result of a posttest score minus a pretest score.

The survey data will be reported as the percentages of students that selected a given answer. The choices were Strongly Disagree, Disagree, Agree, and Strongly Agree.

IV. Results

This section presents the results of the two-sample t-tests and of the students’ responses to the survey question. The quantitative data was analyzed using the statistical package MINITAB.

A. Pre and Post Tests

At the beginning of each semester, the content exam was administered online to all participating students. This instrument was administered again at the conclusion of the semester. Table 1 summarizes the average pretest, posttest and difference score in both the in class and online versions of the course. As this table suggests, there was a statistically significant difference in both the pretest scores and the difference scores.

Table 1 All

	N	Pre-test	Post-test	Difference
In class	149	14.32	18.63	4.31
Online	84	13.33	19.00	5.67
p-value		0.006*	0.399	0.001*

*indicates significance at the 0.05 α-level

The reader will notice that the students in the online version of the course performed, on average, lower than the students in the in class version of the course on the pre-test. The p-value is 0.006, which suggests a highly significant result. Yet, on the post-test, the online students on average performed better than the in class students. This suggests greater gains in the online version of the course than the in class version of the course, and this is further supported by the significant difference found in difference scores. It should be noted that the p-value of 0.001 is very small, indicating a strong result that there was a difference in the amount learned between the online and class versions of *Engineering Cultures*.

One factor that may impact these results is the instructor of the online courses. It is possible that the on line instructors were, in general, better teachers than the in class instructors. Therefore, the next analysis compares online to in class performances when both version of the course were taught by the same instructor.

B. Instructors

Two instructors taught both an online and in class version of the course. They will be referred to here as Instructor 1 and Instructor 2.

The results within Instructor 1's courses are displayed in Table 2. The online students begin the course with significantly lower pretest scores, but end the course with comparable post-test scores. Although the pretest scores were significantly different, the difference scores were not found to be significantly different. The p-value of 0.049 is close to 0.05 which suggests a weaker finding than the results of Table 1.

Table 2 Instructor 1

	N	Pre-test	Post-test	Difference
In class	63	14.29	19.08	4.79
Online	50	13.27	18.72	5.46
p-value		0.049*	0.539	0.243

*indicates significance at the 0.05 α-level

A similar trend is witnessed for Instructor 2. Online students began the class with significantly lower pre-test scores and ended the course with comparable post-test scores. The difference scores were found to be significantly different, suggesting greater gains in the online version of the course. The p-values of 0.015 and 0.004 are small which indicates a stronger result than those of Instructor 1. Considering these results for Instructor 1 and 2 together, the overall significant finding appears to be more strongly impacted by the results of Instructor 2.

Table 3 Instructor 2

	N	Pre-test	Post-test	Difference
In class	45	14.81	18.82	4.02
Online	34	13.42	19.41	5.99
p-value		0.015*	0.433	0.004*

*indicates significance at the 0.05 α-level

C. Survey Data

As previously mentioned the students were requested to take a survey at the end of the course. The question of interest in this investigation was, “I believe I learned more in the online version of the course than I would have learned in a classroom version.” A summary of students’ responses is displayed in Table 4.

Table 4 Survey Data

Instructor	**Strongly disagree**	**Disagree**	**Agree**	**Strongly Agree**	**N**
1	0.00%	39.39%	48.48%	12.12%	33
2	2.94%	55.88%	32.35%	8.82%	34
2	0.00%	25.00%	60.00%	15.00%	20
All	1.15%	42.53%	44.83%	11.49%	87

As this table suggests, most students did not “Strongly Agree” with this statement. Responses tended to be split between “Disagree” and “Agree”. It is surprising that a large number of students disagreed with the statement when the results of the content assessment suggest that online students had greater gains in learning than did in class students.

V. Conclusions

A surprising finding of this investigation is that online students appeared to have had greater gains in knowledge as a result of course completion when compared to in class students. This was true across as well as within instructors’ courses. There are several potential conclusions that can be drawn from this observation. It is possible that online instruction is more effective than in class instruction for the given course content. This is unlikely, since the materials provided in both courses were identical and the primary difference was whether or not these materials could be discussed. Both in class and online students had the option of reading the assigned materials. Another possibility is that there are student factors that could not be measured that influenced the results. For example, students that are more motivated and that are confident in their own abilities may select to complete online courses. These same students may be more likely than the typical student to acquire greater gains regardless of the course structure.

This second conclusion can be further supported by the finding concerning online students’ responses to the survey question. Although the online students displayed greater gains than the in class students on content assessment, many of the online students did not agree with the statement, “I believe I learned more in the online version of the course than I would have learned in a classroom version.” If these students are correct in their own evaluation of their learning, then online learning is not necessarily preferable to in class learning. These students may have performed even better in a classroom setting. Since random assignment was not possible in this investigation, it is difficult to determine whether these students would have learned more in a classroom version of the course.

This study does support the conclusion that both the online and the in class versions of *Engineering Cultures* supports student learning. In both versions of the course, students displayed learning gains. Since online courses have the promise of reaching more students than is possible for in class versions, a next important step in this research is identifying the student factors that influence success in the online environment. Further research is also needed to examine the extent to which these finding may be generalized to other college courses. The success of the online students witnessed in this study may be unique to the *Engineering Cultures* curriculum.

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Appendix A:

1. In France, engineering constitutes an occupation with
   A, a status roughly equal to artisan workers
   B. a status below doctors and lawyers
   C. highest status for those who work in industry
   D. highest status for those who work in government *
2. In France, engineering became linked to the state for the purpose of
   A. bringing society in line with nature *
   B. assuring uniformity of thought
   C. to protect engineering secrets
   D. revealing the genius of the French people
3. After the 18th century, engineering education in France increasingly became a system
   A. Revealing natural merit by objective measures
   B. With mathematics at its center
   C. Applying rational mechanics to analysis
   D. All of the above *
4. How is progress understood in German culture?
   A. as an emphasis on ever-increasing standard of living
   B. as a focus on the individual
   C. as the emancipation of the human spirit *
   D. as a system where Germans earn more vacation than Americans
5. Under the 2nd Reich_____________ become the source of progress and the key vehicle for achieving a unified nation.
   A. education
   B. industry *
   C. agriculture
   D. mathematics
6. Corporations in Japan often ___________.
   A. compete
   B. collaborate *
   C. merge
   D. go bankrupt
7. In the 1980's, the American view of international relations shifted from images of military struggle to economic competition. This shift was connected to a growing fear of what nation?
   A. Canada
   B. Soviet Union
   C. China
   D. Japan *
8. People who believe that their own culture is superior to all others can be characterized as ____________.
   A. media-driven
   B. multicultural
   C. ethnocentric *
   D. congenial

9. The dominant image of competitiveness in the United States is based on __________.
   A. the family
   B. individualism *
   C. teamwork
   D. good vs. evil
10. The majority of engineering schools in the U.S. have established __________ designed to improve the levels of recruitment and retention of minority and women students.
   A. technology initiatives
   B. relaxed graduation requirements
   C. new research facilities
   D. minority engineering programs *
11. The Morrill Land Grant Act of 1862 was described as "An Act Donating Public Lands to the several States and Territories which may provide Colleges for the Benefit of __________ and __________ Arts."
   A. Literary, Mathematical
   B. Scientific, Dramatic
   C. Technical, Non-Technical
   D. Agriculture, Mechanic *
12. The United States viewed the Soviet launch of Sputnik as an achievement of __________.
   A. engineering
   B. capitalism
   C. science *
   D. consumerism
13. What concept describes the dominant image of British engineering?
   A. Theory
   B. Quality
   C. Craftsmanship *
   D. Cost
14. What historical event introduced the concept of "merit" into French engineering and education?
   A. The Enlightenment
   B. D-Day
   C. French Revolution *
   D. The Crowning of Louis XIV
15. Which of the following cultural "elements" does not represent the German emphasis on quality?
   A. 18th and 19th Century Classical Music
   B. The Ultimate Driving Machine (BMW)
   C. National Socialism (Nazism)
   D. Subsistence Agriculture *
16. Which of the following is generally considered a success of the former Soviet Union?
   A. collectivization of agriculture
   B. rapid industrialization *
   C. comprehensive environmental protection
   D. unification of peasants and workers

17. Which of the following is NOT a way that westernization is changing Japanese culture?
    A. Generational tension
    B. Changes in industry
    C. Greater focus on the individual
    D. Rejection of all Western products by the Japanese Government *
18. Which of the following would NOT be found in a Japanese engineering office?
    A. Cubicles *
    B. Uniforms
    C. Exercise music
    D. Large open work space
19. Match the economic/political philosophy with the attribute that best describes it.

C. Communism	A. Laissez-faire economics
B. Socialism	B. State-run economy
D. Anarchism	C. Party-run economy
A. Capitalism	D. Decentralization of power and control

20. Place the following Russian/Soviet governments in order from least recent to most recent.
    4. Stalinist USSR
    3. Leninist USSR
    2. Provisional Government
    1. Tsarist Russia
21. In U.S. companies, engineers working in manufacturing typically have a higher status than those working in design.
    A. True
    B. False *
22. The Communist Party became weaker under Stalin.
    A. True
    B. False *
23. How did British engineers traditionally learn to be engineers?
    A. At traditional universities like Oxford and Cambridge
    B. At apprenticeships supervised by mechanics and engineers *
    C. At middle school taught by engineering faculty
    D. In factories as salaried employees
24. In what area of government did 19th century British engineers have a strong role?
    A. Executive branch
    B. Military endeavors
    C. Colonial projects *
    D. Local construction
25. Where do British students train today to become engineers?
    E. On the shop floor
    F. at Oxford
    G. at Cambridge
    H. at polytechnics *

* Indicates correct answer.