Comparing Learning Outcomes and Content Mastery in Online and Face-to-Face Engineering Statics Courses

Dr. Jamie Douglas, University of Wisconsin Colleges Online

Jamie Douglas is an Assistant Professor with the University of Wisconsin Colleges Online and at the University of Wisconsin – Fox Valley. She completed a bachelor's in civil/environmental engineering from the University of Illinois (UIUC) in 1998 and a Ph.D. in civil engineering from the University of Wisconsin – Madison in 2007. She currently lives in Appleton, WI with her husband and two children.

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Abstract

Online engineering education has expanded rapidly in recent years and many questions have been raised about the learning outcomes and content mastery in online classes as they compare with traditional face-to-face formats. This paper compares the learning outcomes and content mastery for students in an Engineering Mechanics (Statics) course taught in three different modes of instruction. This study was initiated in 2011 with a cohort of three courses: one taught asynchronously online, one taught face-to-face, and a third taught via synchronous audiographics. Students provided feedback on their use of instructional resources, their learning styles, and their attitudes throughout the semester. Content mastery was measured through student performance on proctored exams. Due to the small number of students in the initial cohort of the online course, the assessments were repeated with a second cohort of students in online and face-to-face courses in the spring of 2014.

The results of this study show that in the first cohort (2011), the online students outperformed the face-to-face when given identical problems on proctored quizzes and exams. Attitudes among students in the face-to-face and online classes were similar and generally positive. The performance of students in the audiographics distance class fell into the range between the online and face-to-face classes. However, students who were in the synchronous audiographics class were less satisfied with their mode of instruction despite their competence with the course content.

In the second cohort of students (2014), there was little to no difference in content mastery between students who completed the online and face-to-face sections of the class. Scores on identical proctored exam problems were similar to those earned by the face-to-face students in the initial cohort of 2011. In both cohorts of students, withdrawal and non-completion rates were higher in the online and audiographics courses than either of the face-to-face courses.

Introduction

The number of students enrolled in online classes continues to grow.[1] Surveys from 2011 and 2012 indicate that between 5.5 million and 6.7 million students take at least one online class.[1,6] Though there remains some skepticism about online classes among faculty and administrators[1], a growing body of evidence suggests that students in online classes learn at least as well as, or better, than their face-to-face counterparts.[3,4,7] Additionally, studies have found that online students spend more time with the material than face-to-face students and this may be a benefit to online learners.[7]

However, studies have also noted that online and distance education students have lower course completion rates than face-to-face students.[2,3,5] Some of the factors that influence persistence in online courses include satisfaction, sense of community, and communication.[5]

Research on the effectiveness of online education continues to grow and be applied to different disciplines. This study compares content mastery, course completion rates, and student satisfaction in three modes of instruction of an engineering statics course.

Background

The University of Wisconsin Colleges are part of the larger University of Wisconsin System. The UW Colleges are composed of 13 campuses geographically dispersed across the state of Wisconsin. The UW Colleges mission is to prepare students for success at the baccalaureate level of education. The Colleges offer the first two years of general education including calculus, chemistry, and physics as well as introductory engineering courses and the engineering mechanics courses. The curriculum is offered via face-to-face instruction at six of the campuses and via distance education (DE) to the other campuses. The curriculum is also offered asynchronously through the UW Colleges online program, which is available to all campus students as well as students seeking degrees outside the UW System.

This study was conducted in two cohorts. The first cohort compares students who were enrolled in one face-to-face section of engineering statics at UW Fox Valley, one section offered via synchronous distance education to nine other UW Colleges campuses, and one section offered through the UW Colleges online program. The second cohort compares only students in a face-to-face section at UW Fox Valley and a section offered through UW Colleges online.

The synchronous distance education section was offered via audiographics, or non-online distance education (NODE). Audiographics connects students via a telephone conferencing system and a web meeting using Blackboard Collaborate. The faculty member controls the computer and the meeting in real time. Students are required to attend class at a specified time and day, and the students must be physically present at their campus to attend the course. The online course was offered entirely asynchronously, though students had the option to meet synchronously online with an instructor during online office hours. The face-to-face class met in a traditional classroom, and included a combination of lecture and group problem solving.

Due to the geographically disperse nature of the institution, students did not have all options of course instruction mode available to them at registration. Therefore the students selected their mode of instruction from a limited offering. The online course was available to all students. The face-to-face course was offered at one campus, and the NODE audiographics course was offered at other campuses. Therefore students could select either face-to-face or online at one campus; or they could select audiographics or online from other campuses.

The statics course considered in this paper is part of the typical undergraduate engineering mechanics sequence that includes statics, dynamics, and mechanics of materials. Topics covered include force vectors, moments, equilibrium of particles and rigid bodies, trusses and frames, friction, center of gravity, and moment of inertia.

Methodology

All five sections were taught by the same instructor and used the same textbook. The face-to-face course met three days a week for a 50-minute lecture, and the course was structured with traditional written homework assignments and proctored in-class exams. The audiographics

class met two days a week for 75 minute lectures along with written homework assignments and proctored in-class exams. The online class did not meet, but written material and examples were provided to students. Students submitted traditional handwritten homework, online quizzes, and proctored in-person exams.

In the first cohort of the study, students in all modes of instruction were given a survey form at the beginning, middle, and end of the semester. The surveys asked students about the structure of the class, the learning tools that they were using, the time spent on course material, and how satisfied they were with aspects of the course. The surveys used check boxes, Likert scales, and open-ended response questions. In the second cohort, the students were only given a survey at the end of the semester.

Content mastery for all classes was based on grade performance on a set of common exam problems. The problems were all given in a proctored or face-to-face setting. The exam structure was slightly different for the audiographics and face-to-face classes (which both had 3 exams) and the online class (which had only a midterm and final). In all cases, the common questions were not the entirety of the exam. However, only the scores on the problems which were given to all three classes were considered for the study.

Students who did not complete the course were excluded from the study. This subset included students who withdrew before the 10th week of class (recorded as a W) as well as any student who stopped attending class prior to the 14th week (of 16 total weeks). Any student who completed at least 14 weeks of course material was included in the study.

Results

Persistence

As noted, students who quit participating before the 14th week of class were not included in the results. That number included both students who voluntarily withdrew between the 10th day and the 10th week of class, which is the official withdrawal period, and the students who stopped attending class or completing assignments. Previous studies have found the number of non-completing students to be higher in online than in face-to-face classes. In this study, course completion varied significantly in the online and audiographics courses, with the lowest completion rate in the audiographics course. Course completion was consistently high in the face-to-face course. Table 1 summarizes the course enrollments and number of students who withdrew or failed to complete the course after the 10th day of classes.

Table 1: Enrollment and Course Completion Data

Year	Mode	Enrollment Day 10	Withdrawal	Fail to Complete
2011	NODE	25	10	1
2011	ONL	6	0	0
2011	F2F	25	0	1
2014	ONL	7	1	2
2014	F2F	16	1	0

Cohort 1 survey data

Survey data from the 2011 cohort was used primarily to examine attitudes of students in each mode of instruction and to give the instructor feedback on the types of course tools being used by each group of students. A few common themes emerged from the survey responses.

First, the average amount of time spent working outside of class was very similar for the audiographics and face-to-face students (5.9 hours and 5.4 hours, respectively). Online students reported spending more time with the course material (9.6 hours); however some of that difference is due to the additional "classroom" time added to the other two sections. If classroom time were accounted for, the audiographics, face-to-face, and online students would spend a total of 8.9, 8.4 and 9.6 hours, respectively, with the course material each week. Additionally, the time reported varied widely by individual student, and once adjusted for in-class time was not significant between sections.

Secondly, the attitudes of each set of students varied significantly. Face-to-face and online students reported being happy with their mode of instruction, while audiographics students generally were not. Many reported a difficulty paying attention during lectures where no live person was visible and cited difficulty using the technology during interactive elements of the course. Conversely, online students praised the flexibility of the online class. Students were asked about their recommendations of this course to other students from 0 (not at all) to 5 (Agree). The average scores are provided in Table 2.

Table 2: Satisfaction with Mode of Instruction

	NODE	F2F	ONL
Would recommend this course in this mode of instruction	3.33	4.42	4.67
Would recommend this course in a different mode of instruction	4.40	2.58	4.00

The data combined with student responses suggest that distance education students may prefer a face-to-face learning environment, however that isn't an option on their campus. The lower satisfaction rates are potentially correlated with the higher withdrawal rate, as students choose to wait until the course is available in a different mode of instruction, either at the UW Colleges or at their transfer institution.

The second cohort of students was also surveyed at the end of the semester. An insufficient number of surveys were received from the online students to include in the study. The face-to-face students reported similar satisfaction with their mode of instruction as the first cohort had reported.

Cohort 1 and 2 - Content Mastery

Content mastery was measured from a set of common exam problems given in a live, proctored setting. Students in the audiographics and face-to-face classes took the exams during class time.

Online students were required to schedule a time with a local campus proctor, test center, librarian, or other accepted proctor. Table 3 provides the average score earned by students in each mode of instruction on only the common test questions. The scores have been normalized to 100%.

Table 3: Cohort 1 Content Mastery Scores

Delivery Mode	Cohort	Number of Students Assessed	Average Score (out of 100)
NODE	1	14	82.19
F2F	1	24	77.80
ONL	1	6	86.80

In the first cohort, the online students had the highest average scores on the assessments, followed by the audiographics students and then the face-to-face students. Determining the significance of the results through hypothesis testing was limited due to the low numbers in the online class. However, small sample t-tests indicate no statistically significant differences in the scores between audiographics classes and either of the other two sections. There was a statistically significant difference ($P < 0.05$) between the scores of the face-to-face and online students.

The online statics class was first offered in 2010. The year the initial study was performed would have been only the second group of students to pass through the class. So, the assessment was repeated in 2014 with the second cohort of students. The same pool of questions was used as had been used in the initial cohort of students so that results could be shared across years. Table 4 provides the average score earned by students in each mode of instruction on only the common test questions. The scores have been normalized to 100%.

Table 4: Cohort 2 Content Mastery Scores

Delivery Mode	Cohort	Number of Students Assessed	Average Score (out of 100)
F2F	2	15	79.94
ONL	2	4	80.58

The data from cohort two shows little to no difference in performance of the online students and the face-to-face students. In absolute terms, the face-to-face students did slightly better in the second cohort and the online students did slightly worse as compared to the initial cohort of students. However, none of the data fell outside a normal distribution and the differences are not statistically significant.

Cohorts Relative to Pooled Data

The author acknowledges that the number of students in this study is small. The small class sizes are due to the disperse nature of the institution and the institution's mission of access. Though the study was not specifically conducted in the intervening years (2012-2013), it is possible to

compare overall pooled data for completion rates and final course grades for a four year period from 2011-2014.

The following analysis shows pooled data for sections of the face-to-face statics course and the online statics course offered in the spring semesters from 2011-2014. Data was not available for a pooled group of NODE audiographics students.

Table 5: Enrollment and Course Completion Data

Year	Mode	Enrollment Day 10	Withdrawal	Fail to Complete
2011-2014	ONL	41	8	4
2011-2014	F2F	72	2	4

For the combined data, withdrawal and non-completion rates are higher in the online course than the face-to-face course. In the online class, 29% of all students who attempted the course were not able to complete it, compared with 8% of face-to-face students. As noted previously, there was high variability in non-completion rates by semester. In online sections, the non-completion rate varied from 0%-43%. The percentage of students who did not complete the face-to-face course varied from 4% to 15%. The single year of audiographics data indicated the highest non-completion rate of 44% (Table 1).

The specific quiz and exam questions that comprised the study were the same for years 2011 and 2014, but were not held constant for the intervening years 2012 and 2013. Additionally, assignments and learning tools varied according to best practices for each mode of instruction. However, it is possible to compare final course grades for students in the online and the face-to-face classes over a longer time period in order to provide a larger context to view the small, course-specific data.

Table 6: Final Course Grades (Students who Completed Course)

Year	Mode	Number of students	Average Final Grade	Content Mastery Scores (Tables 3, 4)
2011	NODE	14	81.8%	82.19
2011	F2F	24	79.6%	77.80
2011	ONL	6	88.9%	86.80
2014	F2F	4	81.1%	79.94
2014	ONL	15	81.2%	80.58
2011-2014 (All Years)	F2F	66	80.4%	
2011-2014 (All Years)	ONL	29	83.0%	

From the data in Table 6, the average final grade for each individual section is similar to the normalized scores on the specific content mastery questions. Therefore using final course grades as a proxy for content learning may be reasonable for this data set. With that assumption in mind, the larger set of pooled final grades is consistent with the course specific data. The larger pooled data indicates that the online students are performing at least as well as their face-to-face

counterparts. Statistical analysis indicates no significant differences between the pooled set of final grade data from face-to-face and online students from 2011-2014.

Conclusions

Though this study was performed on small class sizes, the results show findings consistent with prior research in online courses. Student attitudes varied widely across sections, as did course completion rates. Students who completed the course via either of the distance methods (audiographics or online) mastered the content as well as or better than students in the face-to-face section of the course.

Though not the primary focus of this study, the author did find non-completion rates in distance education courses to be higher than in the face-to-face course. The withdrawal rates for the audiographics course were particularly high, and student's low satisfaction scores may have been a factor. The percentage of students completing the online class varied by semester, and the small numbers in both classes do not generate a strong conclusion about student persistence. Notably, the online students who completed the course were as satisfied with the mode of instruction as the face-to-face students.

Online students reported spending slightly more time with the course material than either audiographics or face-to-face students did, even when adjusted for in-class time. The differences in time reported varied widely by individual student and were not statistically significant across sections.

Finally, content mastery (as measured by common, proctored exam problems) was comparable for all three modes of delivery. Specifically, students who completed the audiographics and online classes mastered the content as well as or better than the face-to-face students.

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