

# Applicability of Online Mechanics of Materials Course for Engineering Undergraduate Students

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**Abstract**—In this research, we examine the effects of online lectures on engineering students' course performances and students' attitudes towards online learning. Specifically, we compare performances of students enrolled in a traditionally taught, lecture format Mechanics of Materials course with students in an online Mechanics of Materials course in Summer 2016 and examine the students' attitudes towards learning Mechanics of Materials online. To see the effect of the two different teaching approaches across student types, students are categorized by gender, enrollment status, English proficiency, and grades students obtained for Statics, one of the prerequisite courses for Mechanics of Materials. The findings can highlight the types of students who benefit from an online Mechanics of Materials course. The larger goal of this study is to determine if the online pedagogy can improve students' academic performance for different types of students and to determine its applicability for the university on a larger scale.

**Keywords**—online lectures, online resources, undergraduate students, engineering fundamentals

## I. INTRODUCTION AND BACKGROUND

Large enrollment engineering classes are problematic not only for professors to teach but also for their negative impact on student grades and role in inadequate student learning [1]. Large classes have been correlated with lower effectiveness in stimulating students' interest and in a slower return of assignments [1]. In a review of 95 published articles reporting research into the effects of large classes, Cuseo [2] drew eight conclusions, seven related to teaching and learning experiences. He concluded that a large class increases faculty reliance on lectures, reduces students' level of active involvement in the learning process, reduces the frequency and quality of instructor interaction with and feedback to students, reduces students' depth of thinking inside the classroom, and limits the breadth and depth of course objectives, course assignments, and course-related learning outside the classroom. Furthermore, students' learning and grades are low in courses with large class size. Students report less course satisfaction in large-sized classes and give lower overall ratings (evaluations) for course instruction delivered in large classes [2].

Recently, online learning has become popular. The advantages of online learning include:

- 24/7 access to a wide variety of course materials for students
- Integration of clips of recorded experiments or demonstrations in videos, a more effective and efficient delivery venue to a large group of students than either a large lecture hall or a crowded lab
- Potential for universities to offer a less expensive degree program for students [3]

The U.S. Department of Education in 2010 [4] reviewed research from 1996 to 2008, compared online learning with face-to-face learning, and concluded that, "Students in online conditions performed modestly better, on average, than those learning the same material through traditional face-to-face instruction," and "The effectiveness of online learning approaches appears quite broad across different content and learner types. Online learning appeared to be an effective option for both undergraduates and for graduate students and professionals in a wide range of academic and professional studies."

Since the study was published, online courses have advanced due to internet access and speed, virtual access to university computers to use licensed software and high graphics software, and availability of better and improved online teaching mediums (e.g. Blackboard, Piazza, and Thinkspace), all of which allow for seamless access to online course content and lectures videos and also allow for interaction between students and professors online. This allows easy distribution of course content (e.g. student assignments, exams, grades and online videos), and the increase in number of laptops, tablets, and mobile phones among students allows access to online content anywhere on or off campus.

Despite the advance and availability of technology which makes online learning widely available, there is still a lack of understanding between engineering students' performance in online classes and engineering students' attitude towards online courses, especially for courses (e.g., Statics, Mechanics of Materials and Dynamics) having high enrollment and required for many engineering majors. This study explores relationships between students' demographic characteristics and grades in an online Mechanics of Materials course. Additionally, this study compares grades of students enrolled in the online Mechanics of Materials and the traditionally taught lecture format course.

Finally, the study examines the students' attitudes towards the online Mechanics of Materials course.

In this study, a traditionally taught lecture refers to the section of students taught in a classroom setting with the instructor being physically present. The class duration is 50-minutes and mostly lecture. The class meets five times per week, and students can meet their instructor through an appointment or during office hours for questions or concerns.

An online class refers to the availability of online lecture videos, notes, and materials over the Internet required for the course. Two types of online videos are shared with the students: lectures and example problems. Lecture videos on average are 12 minutes long and they introduce new concepts. The example problem videos are about 10 minutes long, and they contain instructor-solved sample problems. Online students can contact the professor via email regarding questions. Also, these classes offer online office hours where students and professors virtually meet on an assigned day and time.

Research Questions for this study are:

- How do engineering students' grades compare between students enrolled in an online Mechanics of Materials course and students enrolled in the traditional lecture format course?
- Which types of students, in terms of students' characteristics and academic performance, benefit most from taking an online Mechanics of Materials class?
- What are students' attitudes towards learning the mechanics of materials online?

## II. METHODOLOGY

In Summer 2016, Mechanics of Materials was offered as an online course (EM 324XE) alongside the traditionally taught EM 324 at Iowa State University.

To enroll for EM 324XE and EM 324, each student must pass the fundamental prerequisite course, Statics (EM 274). The grades obtained in EM 274 are used to establish the student's academic performance because Statics' concepts and applications are needed in almost every discipline of engineering [5, 6]. Furthermore, many researchers believe that performance in the later course can be directly correlated to success in Statics of engineering [6, 7, 8].

EM 324XE was taught by one of the authors of the paper. The students taking the conventional course did not have access to the online resources. Students enrolled in the online section took tests in a testing center available on campus or found their own approved proctors to preserve the integrity of the learning assessment and also make the scores comparable with the scores obtained from the conventional course students.

### A. Sampling

The population for this study was engineering students enrolled in EM 324 and EM 324XE. The examined course, Mechanics of Materials, is one of the required classes for students majoring in aerospace, mechanical, and civil engineering at ISU. In Summer 2016, students had an option of

enrolling in either section depending on their schedule and preference. The total enrollment for EM 324XE was 40 students and EM 324 was 50 students.

### B. Research Design

In this research, students from two sections were examined: 1) students enrolled in the traditional Mechanics of Materials section, and 2) students enrolled in the online Mechanics of Materials. Student academic and demographic information were obtained from the ISU's Office of the Registrar. Data that were of interest included student's gender, English proficiency (e.g., TOEFL/IELTS score for international students), enrollment type (e.g., full-time or part-time), current GPA, and prerequisite course (i.e., Statics) grade.

In addition to obtaining the mentioned data from the Registrar's Office, we administered an online survey to students enrolled in the online section to understand their attitudes towards learning through online lectures and resources. Survey questions included:

- Describe the course activities that are most helpful and least helpful to your learning in this course.
- What do you like and dislike about the course?
- List the advantages and disadvantages of the online courses as compared to traditional courses.

There were also Likert-type questions related to whether the online materials were appropriate in length, quantity, and quality and whether they supported students' learning in the course.

### C. Data Analysis

This study will employ quantitative analysis to examine the differences in students between those enrolled in the EM 324XE and EM 324 Mechanics of Materials courses.

Quantitative data will be analyzed using SPSS statistical software at the end of Summer 2016. The normality of the dependent variable will first be established. If normality assumptions are not met then an independent sample t-test will be validated using a nonparametric independent sample test and a general linear univariate model analysis. Missing data will be replaced with a multiple imputation approach to avoid reducing the sample size. A multiple imputation approach searches for patterns in available data by creating a probability-based judgment as to what missing data would be and replacing it to create a full data set [9]. To protect the confidentiality of the students, all student identifications will be removed.

## III. RESULTS

For the first research question, comparison will be made between the two groups (online vs conventional classes). Students' final grades will be compared. The difference in final grades will imply if online classes provide learning at least at par with conventionally taught classes.

For the second research question, the students in each section will be categorized based on the following:

- Academic performance – High, medium, or low grades in a prerequisite course (Statics) and current GPA
- Enrollment – Full or part-time
- Nationality – International or domestic student, race or ethnic background
- Gender

A student can fall under more than one of the above categories. Each category's mean score will be established from the grades and GPA obtained by the students for both sections of the course. The difference in each category's score will show which group of students are impacted most by online classes. For example, if the mean score of the low scoring category for the online section is higher than that of their counterparts in the conventional class, but the mid scoring category for both sections does not show much difference, it can be inferred that online classes impact the low scoring category more than the latter.

For the third question, responses to open-ended questions and Likert-type questions will be examined. Common found themes from open-ended questions will be shared in a future paper.

#### IV. FUTURE PLAN

The scheduled test scores and final grades obtained by the students will be analyzed at the end of the summer using the above-mentioned method. Furthermore, student opinions obtained through the survey will help examine their attitudes towards the online Mechanics of Materials course. Inferences made from the results obtained by the academic performance of students in the Summer 2016 cohort will be tested by employing the same research design and methodology on the following Spring 2017 cohort.

#### V. CONCLUSION

Engineering is one of the most sought out degrees in U.S. Universities. With an increasing influx of students (domestic and international), universities will have to deal with high enrollment courses. Online classes could be a good alternative for universities to cope with bigger class sizes without

compromising the quality of education--with the added benefits of cost reduction, a flexible schedule for students, and possibly a better form of learning. This study will add to the literature on students' performance in online engineering classes compared with students in traditional lecture-based classes. Furthermore, the study will highlight the effects and benefits to students of an online course.

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