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Flipped Classes: Do Instructors Need To Reinvent the Wheel When It Comes To Course Content?

Dr. Matthew James Jensen, Florida Institute of Technology

Dr. Matthew J. Jensen received his bachelor's degree in Mechanical Engineering from Rose-Hulman Institute of Technology in 2006. Matthew received his doctorate from Clemson University in 2011 in Mechanical Engineering, focused primarily on automotive control systems and dynamics. During his graduate studies, Matthew was awarded the Department of Mechanical Engineering Endowed Teaching Fellowship. He is currently an Assistant Professor of Mechanical Engineering and the ProTrack Co-Op Coordinator at Florida Institute of Technology. His research interests include applications in automotive/transportation safety, electro-mechanical systems, data analysis strategies and techniques, dynamic modeling, and engineering education.

Dr. Anna KT Howard, North Carolina State University

Anna Howard is a Teaching Associate Professor at NC State University in Mechanical and Aerospace Engineering where she has led the course redesign effort for Engineering Statics. She received her Ph.D. from the Rotorcraft Center of Excellence at Penn State University in 2001.

Dr. Sherry Jensen, Florida Institute of Technology

Dr. Sherry Jensen is an Assistant Professor of Economics at the Florida Institute of Technology. She received her Ph.D. and M.A., both in economics, from Clemson University and a B.S. in economics from Centre College. Her research interests are in applied microeconomics and applied econometrics with specialization in labor economics, industrial organization, and the economics of education.

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Abstract

At universities across the country, flipped classrooms are replacing traditional lectures for many fundamental engineering courses. Flipped classes often use short, lecture-style videos that students view before coming to class. Conventional wisdom in creating these videos says that it is better for the video to be of the actual course instructor rather than a video of someone else. The ubiquity of engineering statics courses across the country would therefore require many faculty at many institutions to make videos of the same material. In this study, faculty from North Carolina State University and Florida Institute of Technology have partnered to test the hypothesis that familiarity with the presenter in the video is optimal for student learning. Engineering Statics courses at NC State have been flipped for several years. The videos produced at NC State have been used in a newly flipped classroom at Florida Tech. For two modules, new videos of identical content were produced featuring the instructor of the newly flipped class. The first group of students saw the NC State videos for all but Module One, wherein they viewed the local professor's videos. The second group of students saw the Florida Tech videos for all but Module Two. To determine if there were differences in performance between students who viewed course videos by the local professor and students who viewed the non-local professor, scores on various assessment tools were analyzed using the ANOVA procedure. This study did not find a significant difference in academic performance between students who viewed videos featuring their classroom professor and students who were instead exposed to a non-local professor. Additionally, an end of course survey revealed that in general students had no preference for who was featured in the videos. Further refinement of the class materials management system and the inclusion of additional course modules are opportunities to improve and further validate this study.

Section 1: Introduction

Over the last several decades, more and more U. S. students are enrolling in college, with nearly forty percent of Americans obtaining at least a two-year college degree[1,2]. The United States has long been the leader in higher education, boasting a majority of the top universities and colleges in the world[3]. As the economy moves away from an industrial base, access to higher education is more and more necessary for economic success, and increasing numbers of Americans are seeking degrees.

Increased enrollment has led to larger class sizes and more competition for jobs requiring college degrees. A college degree has shifted from being an advantage to a requirement, but not all students are equally prepared for college studies[4]. Larger class sizes and increased span of student knowledge have strained the traditional classroom-based lecture model used by most universities.

These issues, along with advances in technologies and communications, have led many faculty, departments, even entire institutions to challenge traditional teaching techniques[5]. Alternative teaching methods including flipped classes, online courses, massive open online courses (MOOC), and hybrid online/classroom-based courses have emerged. Each of these redesigns consumes considerable time and effort, and success varies based on differences in course topics and execution.

A flipped or inverted course design requires students to watch videos, read materials, or complete basic assignments outside of the traditional lecture setting. Starting to flip a course requires producing all of these out-of-class assignments or videos. One way to ease the implementation of a new teaching method is to partner or collaborate with other faculty, departments, or institutions that have already produced materials. This is an especially useful technique for courses that cover standardized topics such as engineering mechanics courses (statics, dynamics, fluids, etc.) as there is little-to-no variation in what material is taught; even the textbooks are very similar[6,7].

This paper describes a collaborative effort to use a flipped class model for an "Engineering Mechanics: Statics" course taught at North Carolina State University (NC State) and Florida Institute of Technology (Florida Tech), one with significant flipped class experience and the other new to the flipped class model. Section 2 covers a review of previous literature. Section 3 describes the methodologies used in this study. Discussions of the study's results are included in Section 4, with conclusions being presented in Section 5.

Section 2: Literature Review

Any good course redesign must start with an understanding of how students learn[8,9]. Higher education strives to incorporate more and more active learning and increased student-faculty interaction, because research shows increases in student understanding and retention due to these course features[10,11]. The same technology that has transformed the world in the last decades is also changing classrooms. Technology has facilitated flipping the engineering classroom, freeing up class time to work problems, do experiments, answer questions, etc.

Providing lecture content outside of class provides more time during class to engage the students, to allow them to work together, to increase student-faculty interaction, etc.[4,5] The idea of inverting the classroom has been used in many disciplines including engineering[12]. Flipping the classroom shares many of the same ideas as the Scale-Up model of classroom redesign which was pioneered for physics and have also shown increased learning in biology, computer science, and math[13, 14,15,16]. But a poorly-designed flipped classroom can actually negatively impact student grades[17].

The concept is simple: show the lecture outside of class and do something more active during class[18]. But do those videos need to be remade every time? As Salmon Khan said, "If Isaac Newton had done videos on calculus, I wouldn't have to … assuming he was good." [19] The use of publicly available third-party videos is common in K-12 education. The Khan Academy has built an international presence on the principle that a good video will suffice no matter who built it[20]. MIT's Open Courseware was initially predicated on the idea that it was best in higher education to have the expert provide the lecture[21]. Indeed, the majority of views of MIT's videos are from outside of the country[22].

However, little adoption of open educational courseware seems to have occurred thus far. One major obstacle that has been shown to exist is a difficulty in identifying appropriate and high quality materials[23, 24]. Another explanation may be issues related to material ownership raised by individual faculty, departments, or even institutions.

Because of these issues, the first step in flipping a classroom isn't using someone else's videos but making instructor-specific videos to seamlessly merge with current curriculum[25,26]. Large course redesign, especially as championed by the National Center for Academic Transformation (NCAT), is very focused on helping faculty develop their courses for their own universities[27]. Collaborations between one university and another, even for courses which are very similar, are less common. The American Society of Engineering Education (ASEE) Virtual Communities of Practice was formed in part to assist in such collaborations and was where this project began[28].

Section 3: Methodology

The flipped class format can be used as a more engaging and effective teaching method; however, flipped classes typically require a large amount of materials to be developed. These materials can require a significant upfront time commitment, which can be a barrier for adoption. This can be especially true for a faculty member that has spent years developing a traditional lecture style course.

Dr. Anna Howard at NC State has several years experience teaching a flipped statics course. Through some trial and error, best practices were identified for the types of materials to use, including: short three to five minute videos summarizing the lectures key topics[29], pencast[i] videos of example problems, skeleton course notes for students to complete on their own, and a website encompassing all of the course materials. Based on feedback received from students in previous years, the short lecture videos were identified as the best and most widely used materials to learn course content.

Dr. Matthew Jensen has a single year of experience teaching engineering statics as a traditional lecture style course. After participating in the ASEE virtual community previously mentioned, the author decided to explore using a flipped course model, leveraging experiences from colleagues at other institutions. For the Fall 2014 semester, a class of 66 students participated in this study during their Engineering Statics course. Six students dropped the course during the semester, leaving a total of 60 students fully participating in this study. Data from the six students who dropped were not included in analysis. Dr. Jensen primarily utilized short lecture videos created by Dr. Howard, supplemented by PowerPoint summary slides created and used by Dr. Jensen in a previous engineering statics course.

This study examined the effects on student learning by using both videos created by and featuring a faculty member from a different institution and videos featuring the Florida Tech professor. For two chapters (approximately 25% of the course material), videos were created by Dr. Jensen to be as similar as possible to Dr. Howard's videos. The chosen chapters were Chapter 5: Equilibrium of a Rigid Body and Chapter 6: Structural Analysis[7]. Those two chapters were covered over a four-week time period (seven lectures) followed immediately by a midterm

[i] A video capture of handwritten notes

exam covering only those two chapters. The 60 students were divided into two groups with similar demographics (sex, GPA, domestic versus international, etc.; see Table 1). Student Group A watched Dr. Howard's videos for Chapter 5 and Dr. Jensen's videos for Chapter 6. Student Group B watched the opposite combination of presenters so as to compare student performance on homework, quiz, and exam questions related to each chapter's material.

Table 1: Student Demographics

Group	Avg GPA	Sex M / F	Visa U.S./ Int.	Major ME / AE / Other	Ch. 5 Videos	Ch. 6 Videos
A	3.09 / 4.0	25 / 7	23 / 9	13 / 10 / 9	Author A	Author B
B	3.08 / 4.0	24 / 4	21 / 7	12 / 9 / 7	Author B	Author A

The course in this study used several software tools to deliver course materials. All course videos were uploaded to YouTube to allow students to view the videos at anytime on the platform of their choosing. All course content and out-of-class interactions between students and the instructor occurred using the Canvas course management tool. In Canvas, videos and PowerPoint materials were organized by week for students to view at their leisure. Canvas does track some information regarding how and when students login to view materials; however, this information is limited and did not allow for accurate tracking of student video views. Students' materials were clearly separated by group. Although it was technically possible for students to view the videos intended for the other group, the instructor believes it is unlikely that students did so.

In addition to Canvas, in-class quiz questions were administered using a classroom response system, TopHat. Quiz questions were asked at the beginning of each lecture and were used to evaluate student preparedness for course topics that were to be covered on that particular day.

Exam, quiz, and homework questions were used to compare student performance between the two student groups. A total of nine exam questions related to the two chosen chapters were asked, five from a midterm exam and four from the final exam. A single quiz and homework assignment were associated with each chapter. Students were allowed to work collaboratively on homework, but quizzes and exams were completed independently. In addition to student performance, a survey was administered at the end of the semester to gauge student preferences related to the flipped class format, course materials, and overall course experience.

Section 4: Results

To determine if there were differences in performance between students who viewed Dr. Howard's and Dr. Jensen's course videos, scores on various assessment tools were analyzed using the ANOVA procedure. Group A was composed of 32 students who viewed Dr. Howard's course videos for Chapter 5 and Dr. Jensen's course videos for Chapter 6. The 28 students in Group B were exposed to the opposite: Dr. Jensen's videos for Chapter 5 and Dr. Howard's videos for Chapter 6. The mean scores of each group for each measure and the associated p-values of each test are reported in Table 2. P-values below 0.05 indicate that statistical evidence leads to the inference that mean scores differed between the two groups.

The first category of assessment tools is performance on in-term exam questions. Three exam questions evaluating knowledge of Chapter 5 material were tested, as well as two exam questions related to Chapter 6 material. Simple comparison of the means across groups reveals highly similar mean values. Further, the ANOVA procedure indicates there is not enough statistical significance to infer that the mean scores differed between groups. All p-values are in excess of 0.396.

Scores on each chapter's homework assignment were also tested for statistical difference across student groups. Again the ANOVA procedure reveals that there is not statistical evidence (p-value= 0.572, p-value= 0.624) to support a difference in mean scores between groups.

The testing for differences in mean quiz scores is the only case for which a difference between groups can be inferred. For the Chapter 5 quiz, Group A (mean=79.95) scored higher than Group B (mean=65.92). This difference is statistically significant as indicated by the 0.001 p-value associated with the ANOVA test. However, the Chapter 6 quiz scores are not statistically different across the two groups. It is difficult to determine why the Chapter 5 score was significant as the exam scores for the same material were not different. Neither group had any students absent from those class periods, which could have skewed results. Given this isolated difference between groups, it is likely attributable to chance. When a hypothesis test is performed with a 5% significance level, there is a one in twenty chance the null hypothesis (no difference between groups) will be rejected when in fact it is true.

Finally, scores on four final exam questions, two from each chapter, were tested. With p-values all exceeding 0.087, a difference in means across groups is not supported by statistical evidence.

Except in the case of the Chapter 5 quiz scores, there was not enough statistical evidence to infer that the mean scores differed between groups. Stated in another way, on the whole statistical evidence is not present to support that viewing course videos featuring a professor different from in-class instruction is either advantageous or detrimental to student performance.

Table 2: Summary results of the ANOVA procedure

Measure		Group A Mean (%)	Group B Mean (%)	p-value
Midterm Exam	CH5 #1	85.90	83.90	0.782
	CH5 #2	78.05	77.80	0.967
	CH5 #3	86.80	85.30	0.743
	CH6 #4	68.64	75.00	0.396
	CH6 #5	40.12	45.72	0.445
HW	CH5	86.25	80.95	0.572
	CH6	83.34	86.55	0.624
Quiz	CH5	79.95	65.92	**0.001**
	CH6	78.91	72.47	0.158
Final Exam	CH5 #1	78.10	81.90	0.453
	CH5 #2	54.50	36.20	0.190
	CH6 #3	63.53	50.87	0.087
	CH6 #4	66.47	71.6	0.399

At the conclusion of the semester, 34 of the 60 students responded to the end of course evaluation. The survey was conducted anonymously so it is unknown how many respondents were from each group. Of the respondents, on average students self-reported that they viewed approximately 70% (standard deviation=28.66) of the videos made available by the instructor. The median respondent viewed 80% of the videos. On average, students rated the videos with a score of 6.48 (standard deviation=2.14) for quality on a scale of 1 to 10, with 10 being the highest quality. In general, students recognized the value of the videos; 47% responded positively when asked if their performance would have improved had they watched more of the video presentations. The majority of students who replied negatively to the performance improvement question were those students who self-reported viewing a high percentage of the videos.

When asked who, Dr. Howard or Dr. Jensen, they preferred watching in videos, 64.7% of respondents expressed no preference. 11.8% expressed preference for Dr. Howard, the non-local professor, and 23.5% expressed preference for their classroom professor, Dr. Jensen. Similarly, 61.76% of the respondents indicated that watching videos of the non-classroom professor did not affect their learning in either a positive or negative way. Together the responses to these two survey items indicate the professor featured in the videos had little impact on students.

Section 5: Conclusions

Research has shown increases in student learning as classrooms move away from traditional all-lecture classes. Developing these course materials takes considerable time and effort from faculty. Sharing the duties between faculty or even between institutions can disperse the effort, but it introduces the worry that students may be negatively impacted if the video content does not feature their own professor. Distance education has long held that forming a bond with the professor is easier when the professor is the one in the video. A flipped classroom may be different because the professor and students retain in-person contact; the video content is not the primary way students interact with their instructor.

This study did not find a significant difference in academic performance between students who viewed videos featuring their classroom professor and students who were instead exposed to a non-local professor. Though small differences exist in mean scores across a variety of performance measures, on the whole these differences are not statistically significant. The qualitative end of course survey revealed that in general students had no preference for who was featured in the videos. Improvements should be made to more accurately track student video views and expand the number of modules that are included in the study. Future research could expand this study to other core engineering courses, other disciplines and additional institutions.

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