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Flipping a Required Mechanics Course with Different Instructors

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Flipping a Required Mechanics Course with Different Instructors

Abstract

Flipped classes are relatively common in engineering education. In a flipped class, the lecture content is typically delivered asynchronously before class via videos, and the in-class activities are redesigned to be more active. In this paper, we will be discussing the flipping of a required sophomore level engineering mechanics course, Mechanical Engineering 220 – Fundamentals of Mechanics (ME220), at the United States Air Force Academy, and in particular, its effect on student performance and their attitudes towards flipped courses. Every student at USAFA is required to take this course regardless of their major. In the Fall of 2022 there were 18 sections of this course with four of the sections taught by three different instructors using a flipped structure. In general, there was no statistical difference in student performance on commonly graded exams between the flipped and non-flipped sections except in a few instances discussed in this paper. In regard to students' attitudes towards flipping, we looked at the effect of the instructor as well as the effect of various other factors such as major, GPA, gender, and activities outside of class, such as participation in intercollegiate athletics. We learned that students' preference for a flipped structure over a traditional structure was strongly dependent on the instructor. Students taught by the instructor who developed the flipped course and who had a lot more teaching experience than the other two instructors indicated that they preferred the flipped structure (46%) to a traditional one (30%). For one of the other instructors, the students indicated that they strongly preferred a traditional structure (65%) over a flipped structure (13%) even though the videos were identical and the class structure was very similar to the first instructor's class. The third instructor's students also preferred the traditional structure, but not so dramatically. For the instructor whose students preferred the flipped structure, we learned that STEM majors tended to prefer the flipped structure more than non-STEM majors, and students involved in extracurricular activities also tended to prefer the flipped structure. Gender did not affect students' preference for the flipped structure, and finally, students who anticipated getting an A or B in the class tended to prefer the flipped structure.

Introduction

Flipped classrooms have become a common teaching choice. For example, a recent article identified more than 1900 publications on flipped or inverted classes [1]. Various flipped approaches and materials are used, with the goal of improving pedagogy by offloading certain learning tasks to times outside the classroom, allowing more effective use of face-to-face time. Bishop and Verleger [2] describe the rise and origins of the flipped classroom, and they define it as "a new pedagogical method, which employs asynchronous video lectures and practice problems as homework, and active, group-based problem-solving activities in the classroom." Additionally, they describe the student-centered learning theories that motivate a flipped environment. Flipped classes tend towards more quizzes and lectures outside the classroom, often via recordings or computer/web-enabled technology. In class, flipped efforts focus less on lectures and more on individual and group activities, often with more individualized and bi-directional interaction between the instructor and the students [1].

Several studies exist for flipped engineering classes, and more specifically for Statics or Mechanics of Materials, which is the subject of our study. A Statics course at Western Michigan University that was redesigned and mostly flipped suggested an improved student passing rate but not with statistical confidence for score differences in the overall learning suggested by final exam scores [3]. Anonymous student feedback was generally positive for the flipped course with some mixed and negative comments. Although it is hard to generalize, this trend seems to be typical for many of the flipped engineering courses studies. Often, while overall exam and course grades are only marginally improved (or unaffected), the withdraw or fail metrics can be improved (when tracked) and the student experience and engagement is sometimes improved as measured by quantitative and qualitative surveys. For example, Holdhusen [4] found that a flipped Statics course had essentially unchanged final exam scores, with mixed perceptions regarding the flipped structure. A second flipped offering actually had lower numerical final exam scores as compared to the prior five semesters of the traditional course, but the difference was not statistically significant. Additional studies exist for flipped Mechanics of Materials courses [5-8] and a blended Statics course [9-10] recently concluded that "the flipped classroom results in greater student engagement and a higher level of student satisfaction with both the course and the instructor, but the impact on student performance, however, is inconclusive."

Flipped classes may offer improved long-term knowledge retention. A ten-year study of an engineering Statics course at North Carolina State University [11] found that students in the flipped Statics course were better prepared for a subsequent advanced course (i.e. Dynamics) as more passed on their first attempt as the course transitioned from being traditional to flipped, and flipped with revisions (88%, 91%, and 94% respectively). Additionally, the Dynamics grades were higher for the students who took the flipped Statics course.

Some studies were done sequentially, with multiple traditional semesters followed by a switch to the flipped format. This makes it hard to deduce if the changing course, student population, and/or instructors influenced the traditional vs flipped comparison. Additionally, for some studies it is unclear if the same exams and graded events were used for the traditional and flipped format classes. Many studies also have limited data as researchers are eager to report the new teaching experience they tried.

Our study compares traditional and flipped sections for a required statics and strength of mechanics course at the United States Air Force Academy (USAFA). The traditional and flipped sections were taught concurrently, all students were given the same assessment exams and projects, and there were 395 students in sections with a traditional structure and 113 students in sections that were flipped. One key difference between our study and others is that all students at USAFA are required to take this course, and as a result, not all of the students were majoring in engineering. Approximately 62% of the students self-identified as having a STEM major, that is some sort of technical major, with 38% indicating a non-STEM major. We did not have data on the percentage of engineers specifically. This study had several objectives:

- Determine if flipping affected student performance on commonly graded exams.
- Evaluate student engagement in the flipped class based on self-reported participation in pre-class activities.

- Identify why some students preferred a flipped structure and other students preferred a traditional structure.
- Identify best practices for new instructors who are planning to teach a flipped class.

Description of the course

ME220 is one of many STEM "core" courses that all students, both engineering and non-engineering majors, are required to take at USAFA. This core course focuses on statics and mechanics of materials, and it is the first engineering course the students take. In the fall semester of 2022, a total of 508 students took the course in 18 sections taught by 11 different instructors. Instructors teach between one and three sections of the course. In the Fall of 2022 four sections of the course, taught by three different instructors, used a flipped structure. The three different instructors are described below:

- Instructor 1 – Has taught for over 33 years, mostly in the area of mechanics (statics, dynamics, system dynamics, and vibrations). Taught two sections flipped.
- Instructor 2 – First year teaching. Taught one section flipped and two sections with a traditional structure.
- Instructor 3 – Has taught for 7 years, mostly in the area of thermofluids. Taught one section flipped but was only assigned to teach the course one week before the start of the semester. He also taught two different courses that semester for a total of three preps.

Each class had both in-class and out-of-class activities. A brief description of these activities for the classes taught by the three different instructors is shown in Table 1.

Table 1 – Class activities

Activity	Instructor 1	Instructor 2	Instructor 3
Pre-class videos	Three short videos. Created by Instructor 1	Three short videos. Instructor watched all videos before class	Three short videos. Instructor did not watch all videos before class
Notetaker	Collected	Encouraged but not collected	Self-reported completion on in-class quiz
Homework	Two or three problems per class session	Same as 1	Same as 1
Homework grading	Graded by students using posted solutions, turned in on Blackboard	Just completion, turned in on Teams	Graded by students in class, self-reported scores
In-class quiz	Over material in videos, allowed to collaborate with neighbors, collected and graded (5 to 10 minutes)	On their phones, competition based, over reading and previous material, all multiple choice	Same as 1
Review and question time at start of class	5 minutes, one slide	10 to 15 minutes	5 to 10 minutes
Boardwork	About 30 minutes. Always completed one homework problem and often more.	About 30 minutes	About 30 minutes

Pre-class activities

All of the instructors used the same videos, which were developed by Instructor 1, for each lesson. There were usually three videos posted for each day's lesson. One video was a lecture over the technical material, and the other two were example problems. The videos were typically 7 to 10 minutes long. The total running time for all three videos was usually between 20 and 30 minutes. We tried to give the students at least 30 minutes in class to work on the next homework assignment to combat the perception that flipped classes are more work since they are required to watch the videos outside of class.

Students were asked to complete a "notetaker" while watching the videos. As shown in Table 1, this was required and collected for Instructor 1, but for the other two instructors it was encouraged, but not collected. The purpose of the notetaker was to help students stay engaged while watching the videos and to ensure that they would have a good set of notes. For the lecture material, the notetaker consisted of a copy of the PowerPoint slides with blanks for students to write in key equations. For the example problems, the notetakers consisted of the problem statements and room to write down the solution from the video. The notetakers were also intended to provide some accountability for watching the videos.

In addition to watching the videos and completing the notetaker, students would also write-up the two or three homework problems from the previous lesson that were due at the start of class. The problems were typically graded by students in class.

In-class activities

In general, the in-class activities were similar for all three instructors. The class started with a brief quiz over the material covered in the videos. For Instructors 1 and 3, the quiz was often started individually, but after about 5 minutes, students were allowed to work with the people around them. Instructor 2's quiz was delivered using the polling software and the questions were all multiple choice.

Following the quiz the instructors presented a very quick summary of the key ideas from the videos, and there was some time for students to ask questions. Then, if homework was due, it was graded in class. Finally, the remainder of the class, typically at least 30 minutes, was used for "boardwork." During boardwork, students were asked to get out of their chairs and work on the whiteboards in groups of typically two or three students, although depending on the size of the class, sometimes the groups were four students. Boardwork is possible at USAFA because our classes are usually less than 30 students per section and the classrooms have whiteboards on multiple walls. For Instructor 1, students were not allowed to work on their own or to stay at their tables, and they were given instructions that the goal of the boardwork was not only to complete as much of the homework as possible, but also to make sure everybody in the group understood the material. For Instructors 2 and 3, students were strongly encouraged to work on the whiteboards, but it was not required. Approximately 80% to 90% did work on the whiteboards, with the remainder working at their tables. Regardless of where they worked, the instructors made sure they were working on the problems. At the end of class, students took a photo of their

boardwork to use when they wrote up the homework, which was due at the start of the next class period.

Assessment

The exams and graded events were identical between the traditional and flipped sections. To assess student mastery of the technical material, we compared students' scores on the three exams and on the final exam for the traditional and flipped sections. Consistency in grading is an important requirement for this course. To achieve this, after the exam is collected, all the instructors gather in the department's conference room for a "grading party." Multiple instructors grade each problem, but each instructor is typically assigned to grade only one problem. All instructors use a common rubric for each problem and discuss any issues together to ensure consistency. Due to the large number of students and the requirement to have grades turned in quickly, the final exam is multiple choice, so consistency in grading is not an issue for that exam.

A questionnaire focused on the activities in the flipped class and the students' attitudes towards the class was given at the end of the semester. This questionnaire was voluntary and anonymous.

Discussion and results

In Table 2 is shown a comparison of students incoming GPA and their performance on the exams for the students in the sections taught with a traditional structure and those taught using a flipped format by the three instructors. Since Instructor 2 also taught two sections using a traditional structure, the results from these sections is also included in the table. To analyze the difference between the traditional and each flipped group, we used a Welch's t-test. As shown in Table 2, there was no statistical difference ($p<0.05$) for most of the exams, but there were three instances where the exam was lower and statistically significant: Exam 1 and 3 for Instructor 3 and Exam 3 for Instructor 2. Why these specific exams were lower was not clear to the instructors. We plan to analyze the data more thoroughly to determine the effect of the incoming GPAs of the students on their performance in the flipped class, but as of the writing of this paper, this analysis is not complete. For example, we want to determine if the students with the higher GPAs, or the lower GPAs, performed differently than students with similar GPAs in the classes with a traditional structure. For Instructor 2, the differences between exam scores for students in his flipped section and his two traditional sections were not statistically significant.

Table 2 - Comparison of students' performance on commonly graded exams for the traditional and flipped courses. The * indicates a statistically significant difference (P<0.5).

Structure	Incoming GPA	Exam 1	Exam 2	Exam 3	Final Exam
Traditional (N≈395)	3.11	80.2%	75.8%	81.0%	75.9%
Instructor 1 flipped (N≈60)	3.13	81.7%	78.0%	82.4%	71.8%
Instructor 2 flipped (N≈24)	3.12	81.0%	79.8%	75.2%*	75.2%
Instructor 2 traditional (N≈46)	3.10	77.1%	78.0%	80.4%	75.4%
Instructor 3 flipped (N≈29)	2.94	65.5%*	71.5%	73.5%*	71.9%

Pre-class activities

On the last day of class students were asked to complete an anonymous questionnaire about the course. The questionnaire was administered via Blackboard, and all of the instructors strongly encouraged their students to complete it (with different degrees of success). Response rates are shown in Table 3.

Table 3 – Response rates for the questionnaire

Instructor	Number of responses to survey
1	54/60 (90%)
2	12/24 (50%)
3	23/29 (79%)

Students were asked questions about how often they watched the pre-class videos and how helpful they found them. Figures 1 and 2 show the responses for the lecture video and Figures 3 and 4 show the results for the example problem videos. From these figures it is clear that a much larger percentage of students in Instructor 1's class indicated that they "Always" watched the videos and found them "Very Helpful." The videos used in all the classes were identical, but perhaps the fact that Instructor 1 was the person who created the videos had an effect, although another study did not find a significant difference in academic performance between students who viewed videos featuring their classroom professor and students in classes where the instructor did not make the videos [12]. Many more students in Instructor 2's and Instructor 3's classes indicated that they "Rarely" or "Never" watched the videos. Even though a smaller percentage of students in Instructor 2's and Instructor 3's sections indicated that they "Always" or "Usually" watched the videos, a relatively large percentage of students indicated that they found the videos "Very Helpful." or "Helpful."

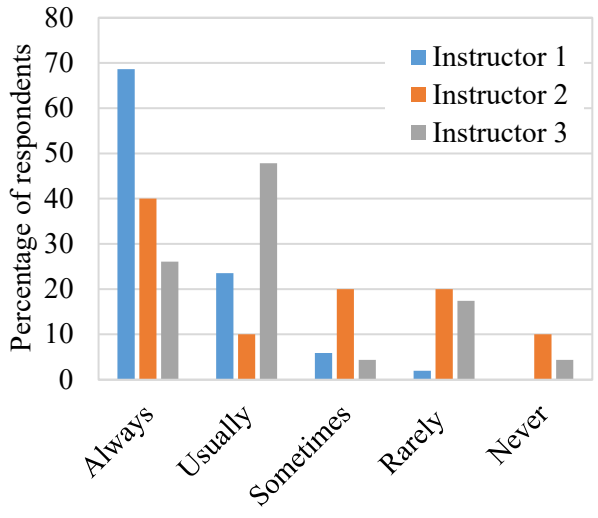

Figure 1 – Answer to the question "How often did you watch the lecture videos before class?"

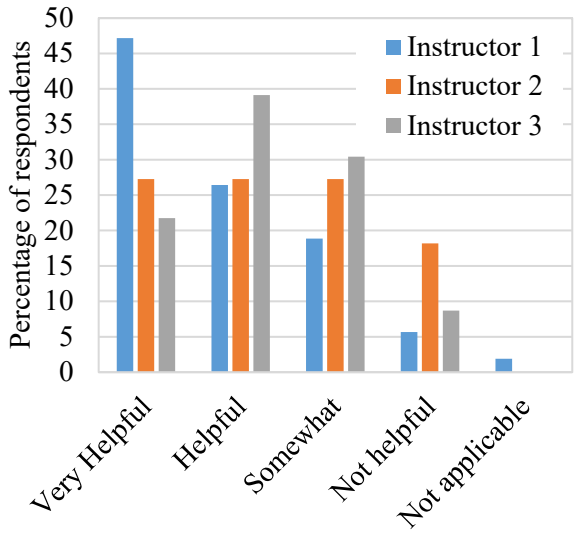

Figure 2 – Answer to the question "In terms of learning the material, that is, preparing you to solve ME220 problems, how helpful were the lecture videos?"

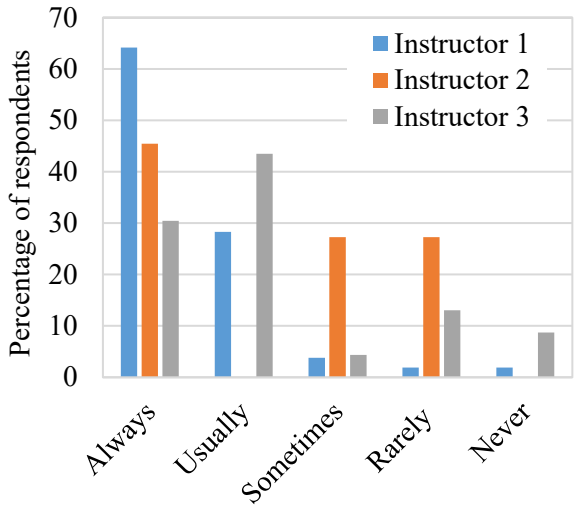

Figure 3 – Answer to the question "How often did you watch the example videos before class?"

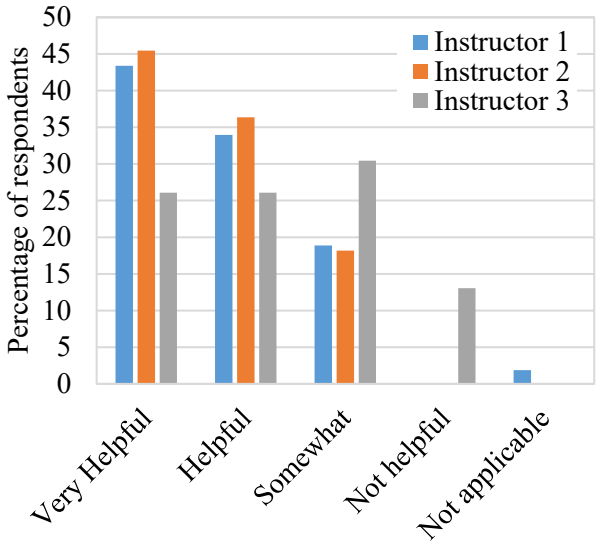

Figure 4 – Answer to the question "In terms of learning the material, that is, preparing you to solve ME220 problems, how helpful were the example problem videos?"

Students were asked, "How often did you complete the notetaker while watching the videos?" and "How helpful was filling out the notetakers in keeping you actively engaged while watching the videos?" The results for these questions are shown in Figures 5 and 6, respectively. Similar

to the questions about the videos, a much larger percentage of students in Instructor 1's sections indicated that they "Always" completed the notetaker and found them "Very Helpful."

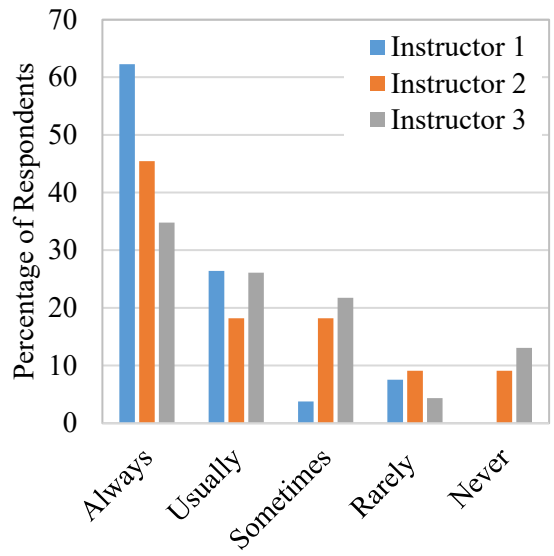

Figure 5 – Answer to the question "How often did you complete the notetaker while watching the videos?"

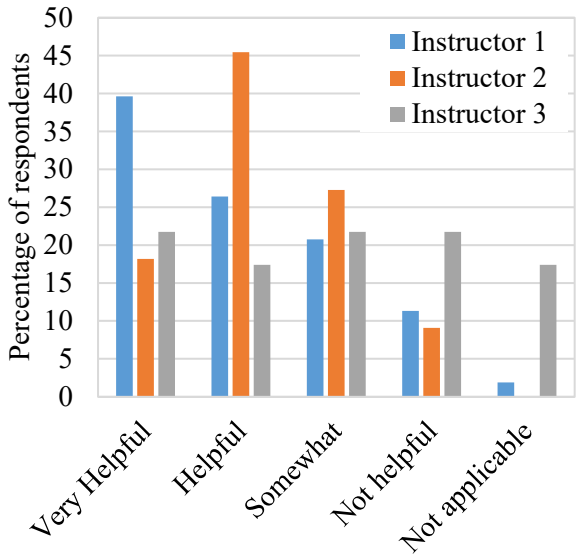

Figure 6 – Answer to the question "How helpful was filling out the notetakers in keeping you actively engaged while watching the videos?"

In-class activities

In addition to asking students about the out-of-class activities, we also asked them to evaluate the in-class activities. As discussed earlier in this paper, the in-class activities included a brief quiz, a quick review of the lecture material, grading the homework, and active engagement via boardwork. Figure 7 shows the responses to the question, "In terms of learning the material, that is, preparing you to solve ME220 problems, how helpful were the in-class quizzes?" and Figure 8 shows the responses to the question, "How helpful was the quick review of the lecture material at the start of each class in reinforcing the main points from the videos?" In general, the quiz at the start of the class was viewed as "Very Helpful" or "Helpful," but there were almost 30% of the students in Instructor 2's and Instructor 3's sections who only found them "Somewhat" helpful or even "Not Helpful." Since some of the questions were more conceptual in nature, the students may not have thought that these problems actually helped prepare them to solve mechanics problems. Based on comments, the reason some students did not view the review positively was because they said that they had already watched the videos and were prepared for class, so the quick review was unnecessary. Not surprisingly, students who indicated that they did not watch the videos often tended to find the quick review "Helpful" or "Very Helpful."

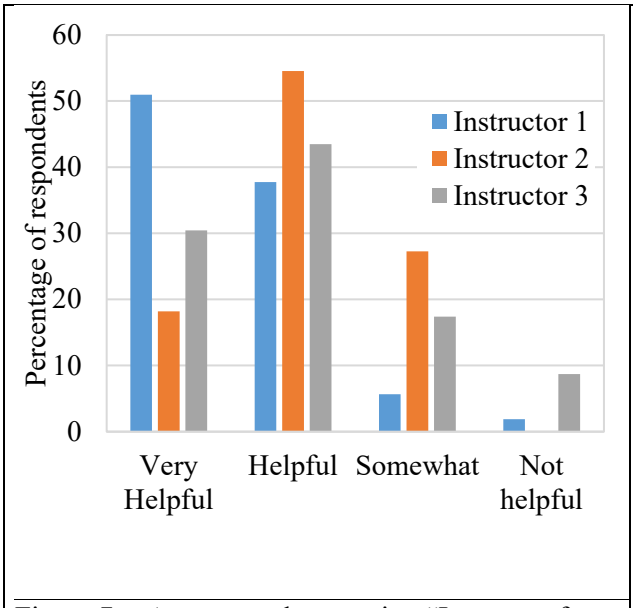

Figure 7 – Answer to the question "In terms of learning the material, that is, preparing you to solve ME220 problems, how helpful were the in-class quizzes?"

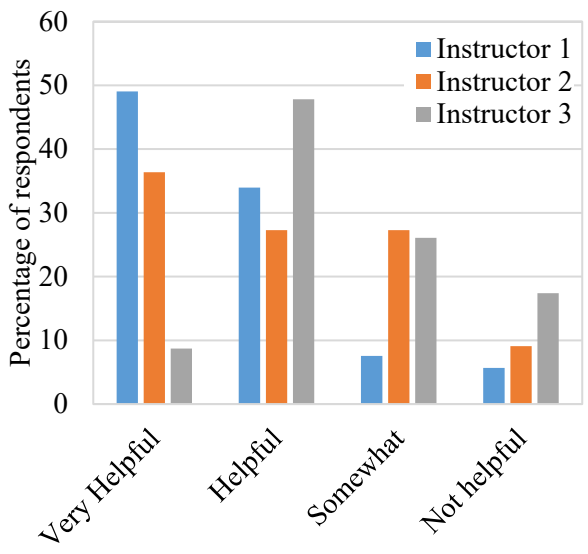

Figure 8 – Answer to the question "How helpful was the quick review of the lecture material at the start of each class in reinforcing the main points from the videos?"

The primary in-class activity was "boardwork," that is, students working in groups on the homework assigned that day. In Figure 9 is shown the results of asking students, "In terms of learning the material, that is, preparing you to solve ME220 problems, how helpful was the boardwork?" and in Figure 10 is shown the results from the question, "During boardwork, how helpful was my coaching (walking around and talking to each group)?" From Figure 9, students in Instructor 3's section found the boardwork much less helpful than the other instructors' students did. From Figure 10, Instructors 2 and 3 also had almost 30% of the students indicate that the coaching during boardwork was only "Somewhat Helpful." It is possible that Instructor 1, who has many more years of experience in teaching mechanics courses than the other instructors, was more adept at managing the room and providing coaching during boardwork.

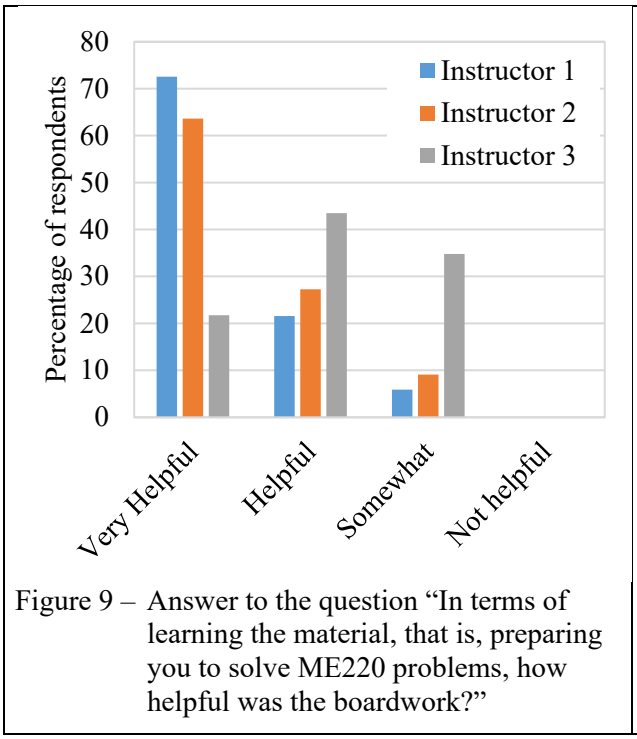

Figure 9 – Answer to the question "In terms of learning the material, that is, preparing you to solve ME220 problems, how helpful was the boardwork?"

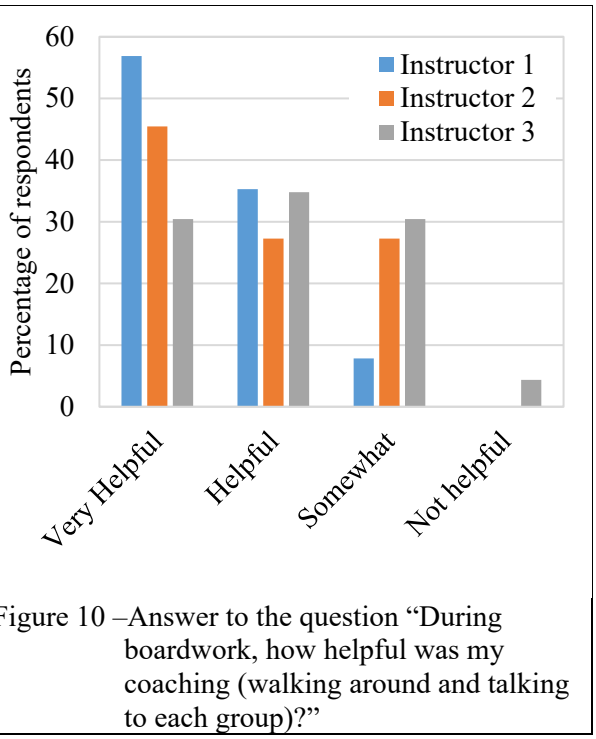

Figure 10 –Answer to the question "During boardwork, how helpful was my coaching (walking around and talking to each group)?"

We asked students the question, "One of my goals for the boardwork was for the members of your group to help one another learn how to apply the principles in this class to solve mechanics problems. How often do you think your group accomplished this?" Clearly from Figure 11 there was a significantly larger percentage of students in Instructor 2's and Instructor 3's sections who indicated that they did not have this attitude towards the boardwork. This may be due to the way boardwork was explained and motivated in the different sections.

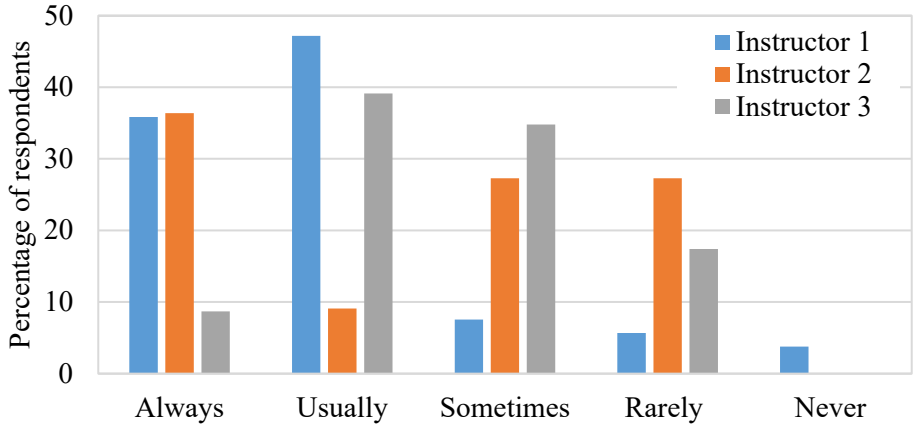

Figure 11 – Answer to the question "One of my goals for the boardwork was for the members of your group to help one another learn how to apply the principles in this class to solve mechanics problems. How often do you think your group accomplished this?"

Other question

We asked students to rate their overall learning experience in this flipped class compared to other conventional courses, and the results are shown in Figure 12. Clearly, a much larger percentage of students rated their learning experience as "Poor" or "Very Poor" for Instructor 2 and Instructor 3. Instructor 1 had more than twice the percentage of students indicate that their learning experience was "Very Good" or "Good" than the students in the other sections.

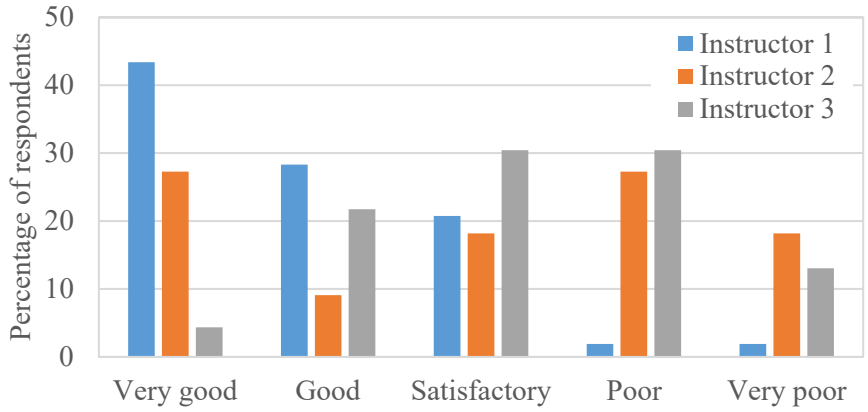

Figure 12 – Answer to the question "How would you rate your experience in this flipped class compared to a conventional course?"

We also asked students to rate their workload compared to that of students taking the course using a traditional structure. The results from this question are shown in Figure 13. Interestingly, Instructor 1's student responses were in a bell curve. The other instructors' students generally rated their workloads as "Much More" or "More." This result is surprising because Instructor 1 required his students to scan and submit their homework and notetakers on Blackboard whereas the other two instructors did not. One possible explanation is that Instructor 1's students were able to complete more of the homework during boardwork, thereby giving them back the time they spend watching the videos. Why a much larger percentage of students in Instructor 2's class rated the workload as "Much More" is not clear since all the assignments were identical.

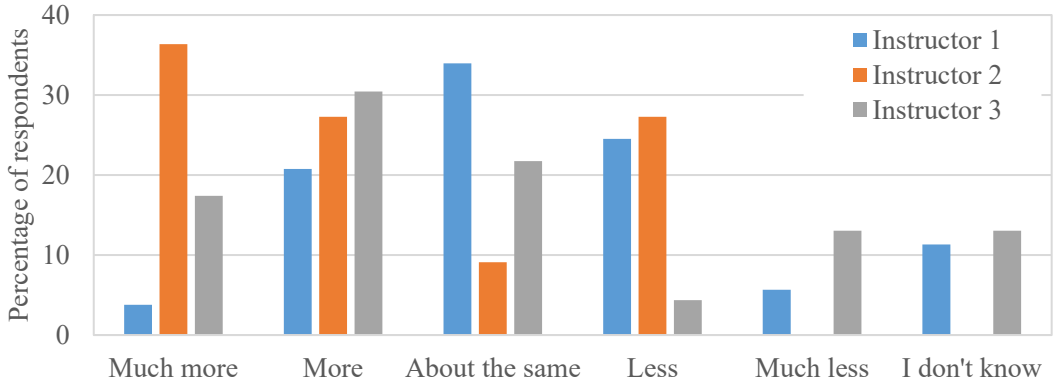

Figure 13 – Answer to the question "In your opinion, how much time do you think you spent on this course compared to your peers in other non-flipped sections?"

Investigation of student preference in class structure

Figure 14 shows the responses to the question, "After taking this class, do you prefer a flipped or a traditional structure for a STEM course?" There was clearly a significant difference in the answer to this question depending on the instructor, with a much larger percentage of students preferring the traditional structure for Instructors 2 and 3. The only group that preferred the flipped structure was Instructor 1's section.

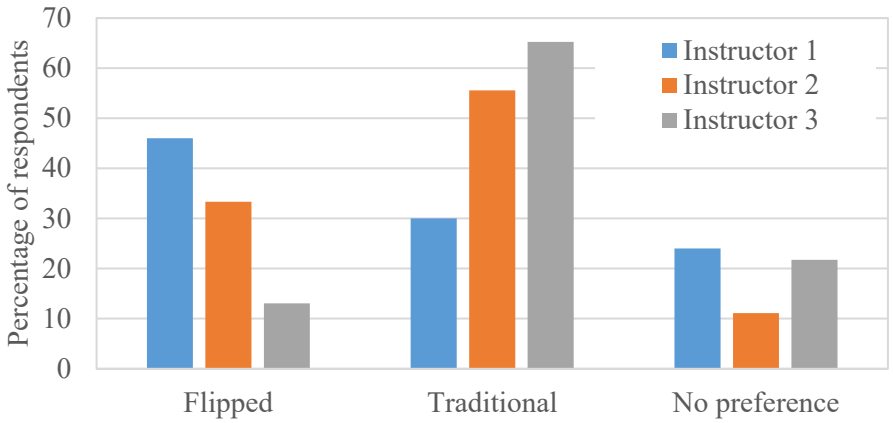

Figure 14 – Answer to the question "After taking this class, do you prefer a flipped or a traditional structure for a STEM course?"

To better understand which class activities best correlated with students preferring the flipped structure, we examined the answers to questions about the pre-class activities. We believe these activities are a good indicator of student engagement in the flipped class structure. In Figure 15 is shown a comparison of preferring the flipped structure to "Always" watched the videos and completing the notetakers. There was a clear correlation between always doing these activities and preferring the flipped structure.

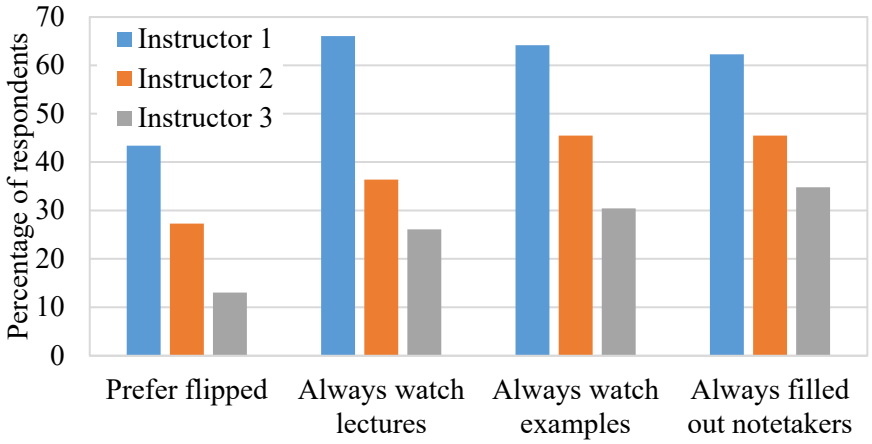

Figure 15 – Comparison of preferring flipped structure and how often students said they "always" completed the pre-class work.

We asked a variety of questions about students' grades, out-of-class activities, and gender to see if any of these factors correlated with a student preferring the flipped structure. Figure 16 shows Instructor 1's students' preference for flipped or traditional as a function of various factors such as how they would characterize their major (STEM vs non-STEM), are they involved in an extracurricular activity that takes more than 20 hours per week, and gender. All groups preferred the flipped structure except non-STEM majors, where the same percentage of students preferred flipped and non-flipped, and students who were not engaged in time-consuming extracurricular activities. No meaningful results for these questions were possible for Instructor 2 due to the small number of responses, and for Instructor 3, the only group that had an equal preference for the flipped and non-flipped structures were those with time-consuming extracurricular activities, such as intercollegiate athletes. This is probably because they miss a lot of class due to travel, and the videos allowed them to easily stay caught up in class.

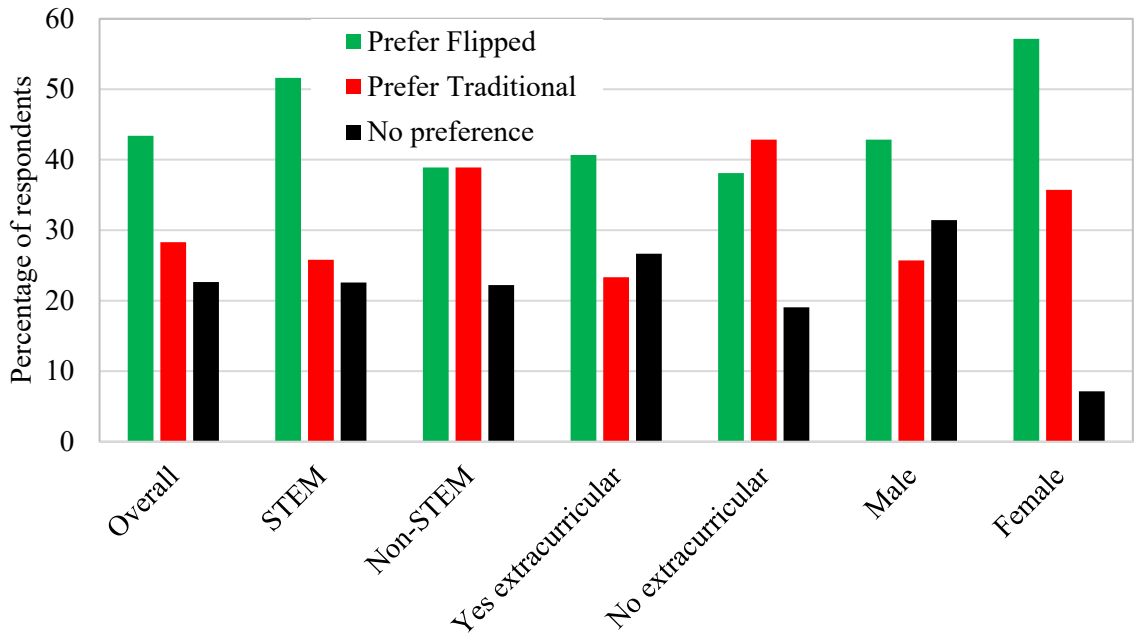

Figure 16 – Class structure preferred as a function of major, participation in extracurricular activities and gender for Instructor 1

We also investigated student preference for the flipped structure for Instructor 1's students as a function of student incoming GPA and expected grade in the class, as shown in Figures 17 and 18, respectively. In these figures, the vertical axis is the number of students rather than the percentage. This was done since the number of students in each category was quite different from category to category. From Figure 17 it is clear that every GPA group preferred the flipped structure except students who had an incoming GPA less than 2.3. There were only two students in this category, and one of them preferred a traditional structure while the other had no preference. From Figure 18, it can be seen that students who expected to receive an A or B in the

class preferred the flipped structure by a 2 to 1 ratio, while more of the students expecting a C in the class indicated that they preferred a traditional structure.

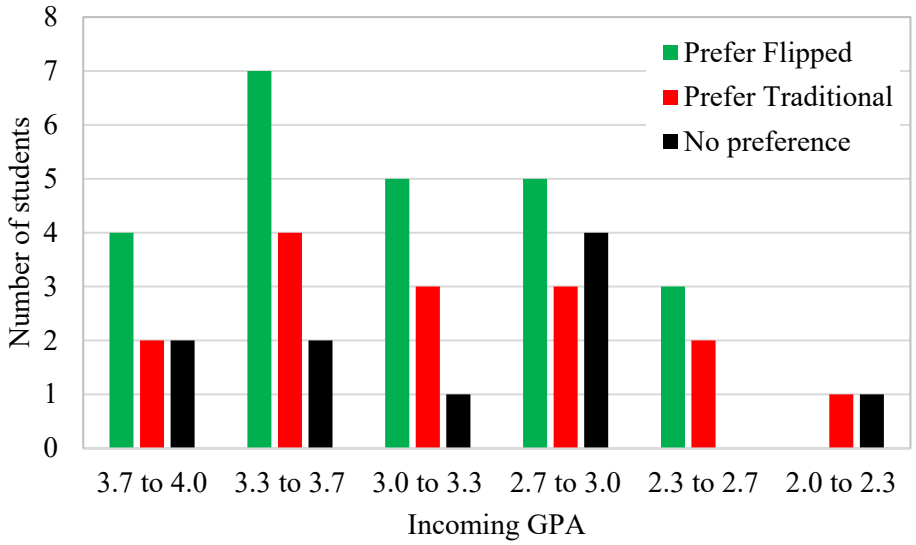

Figure 17 – Class structure preferred as a function of incoming GPA for Instructor 1

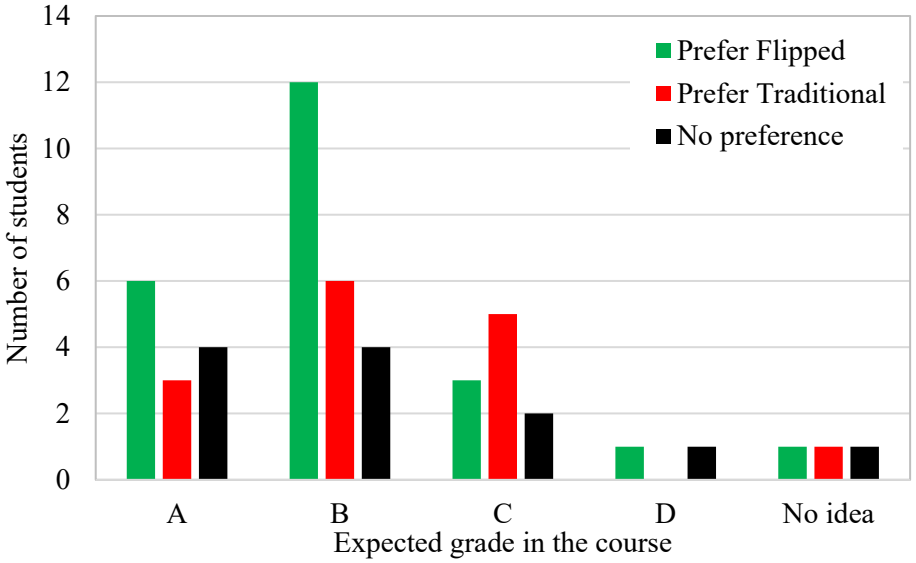

Figure 18 – Class structure preferred as a function of their expected grade in the course for Instructor 1

Observations from instructors

In this section we will present some observations from the faculty members who taught the course but did not contribute to the development of the flipped course materials.

Instructor 2

As a brand-new faculty member, it was an interesting experience for me to teach two sections using a traditional structure and the other using a flipped structure. One of the challenges for me was using videos that were developed by somebody else. I think I explained some topics differently than the videos did, which may have confused some students. Even though I watched all the videos, I would forget certain things that were mentioned, which may have damaged my credibility with my students. I also struggled in getting my students to buy into the flipped course concept. I should have used stricter measures at the beginning of the course to ensure that students were watching the videos and completing the notetakers before coming to class. I was torn between wanting to help those who were not putting in the work outside of class and just leaving them to flounder. As a result, the review I gave at the start of class was probably too long, and it may have contributed to some of them feeling that they did not need to complete the pre-class work.

My favorite aspect of the flipped class structure was the ability to do more boardwork than we could in my traditional sections. I enjoyed interacting with my students while they worked on the whiteboards. I disliked the feeling that I was unable to tailor the in-class activities more due to wanting to respect the flipped format. That is, I wanted to make sure they had 20 to 30 minutes of boardwork to work on their homework to make up for the time they were supposed to spend before class watching the videos. I would possibly teach this way again, but I'm not sure. If I do, I will definitely change how I approach collecting assignments and how I establish my expectations for the pre-class work. I will also make the review at the start of class shorter so that we can focus on other activities.

Instructor 3

Overall, I enjoyed teaching ME220 in a flipped format, and I would definitely do it again given the opportunity. I found the workload comparable to teaching a traditional class, particularly because I don't teach ME220 every year. Instructor 1 provided all of the flipped classroom materials. I did find that I had much less autonomy for the class than I would for a class that I have complete control over. I think an oversight on my part was in not requiring the notetakers, but rather just trusting that the cadets would do them (or take alternative notes). I imagine many did not fully understand the value of the notetakers, and as a result, they did not complete them in a rigorous fashion. It would have been nice to have statistics on the students' video watching rather than simply relying on self-reported data. For me, the semester I taught this course was the most oversubscribed in my seven years at USAFA. Teaching three different courses together with rigid research deadlines made for a very rough semester. As a result, I was only able to watch approximately 60% of the videos.

For a new junior faculty member teaching this course using a flipped structure, I would emphasize that for a flipped course to be valued by the students, it is necessary to enforce usage of the resources that are provided with the flipped course. I think we had excellent materials, but some students chose not to use them, and hence regressed to the "I want you to spoon-feed me lectures" approach. I think Instructor 1 was very effective in convincing his students of the value

of the flipped materials by forcing them to use the materials, and then as the semester went on giving them more freedom to choose how much effort to devote to each activity. For me, the ideal scenario would be to require the students to use all the resources (watching videos, filling out notetakers) for some initial period of time and then relax the requirements based on merit. For example, all videos and notetakers could be mandatory for everyone up to exam one. For students that earn an "A" on the exam, some of these would become optional. This policy would allow some of the talented/hardworking students to skip tasks they may perceive to be less useful, and if they perform poorly on exam 2, it may encourage them to go back to the methods they used before exam 1. My favorite part of teaching this course was the increased time available for boardwork during class. The students and I both liked the boardwork experience.

If I teach this class again, I will make the notetakers a ticket to enter the classroom. Each day approximately 10% of the notetakers would be graded and the others would be checked for completion. In terms of the activities in class, I would spend approximately 5 minutes for homework grading and 5 minutes for the quick review of the video material. I would also keep the 10-minute in-class quiz (i.e. 5-8 minutes for them to work and 2 minutes for active discussion), but to save time, I might require them to come to class with the quiz already completed. In that case, the "quiz time" would be for them to check their work with their partners and have discussion. I would be sure that for every class I allotted a minimum of 25 minutes for boardwork since the total running time for the videos for each lesson was typically less than 25 minutes.

Conclusions and recommendations

In this paper, we discussed the flipping of a required sophomore level engineering mechanics course, and in particular, its effect on student performance and on students' attitudes towards flipping. Based on the results from this study, we can conclude the following for the flipping of ME220:

1) In general, flipping ME220 did not seem to statistically influence student grades on commonly graded assessments.
2) While overall performance may not be affected by a flipped versus a traditional structure, the embracing of the flipped approach does seem to correlate with instructor and some student situations (e.g. time-consuming extracurricular activities or not, STEM vs non-STEM majors).
3) Classes in which a larger percentage of students indicated that they always watched the videos and completed the notetakers also had a larger percentage of students who preferred the flipped structure.
4) The implementation of flipped materials/practices will vary between instructors. Variations may be due to the instructor's preferences, personality, teaching experience, and/or workload due to other courses, service commitments to the university, and research commitments in any given semester.

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