ASEE 2022 ANNUAL CONFERENCE
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MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE

Paper ID #37034

EXAMINING THE IMPACT OF ONLINE LECTURE VIEWING BEHAVIOR ON STUDENT PERFORMANCE IN A FLIPPED CLASSROOM BLENDED COURSE

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Abstract

Blending online and face-to-face instruction through lecture videos and reduced classroom seating time has shown to be beneficial for students in the learning process. As per literature, blended learning has demonstrated greater student successes rates amongst students across many disciplines [1]. Previous studies by the authors on implementing blended learning in a high-enrollment engineering course in Dynamics also corroborate these findings [2]. Consequently, the authors expanded the implementation of the blended model into the next advanced course in the engineering undergraduate curriculum, Vibrations and Controls. In this study, while examining the efficacy of the blended model in enhancing student success rates, the authors delved deeper and adapted a more individualized approach in examining the effect of students' online lecture viewing behavior on their course performance. Several instructional videos for all core course concepts in Vibrations and Controls were created in the blended course and delivered through the Panopto video hosting platform. Learning analytics data were captured as each student interacted with the videos stored in Panopto and correlated with their course grades. Student satisfaction on the blended course delivery was gauged through an IRB-approved course survey. Preliminary results on the impact of student online lecture viewing behavior on student success and student satisfaction in the blended course are summarized and presented in this brief paper.

1. Introduction

STEM education in recent years has shifted from traditional face-to-face instructional methods to blended instructional methods. A blended approach combines face-to-face and online instruction while reducing in-class lecture time [3]. In this model, online instruction is mediated through lecture videos while lecture time is devoted to problem-solving activities [4]. The blended approach also encompasses the flipped-classroom pedagogy, an approach that inverts instruction traditionally occurring inside the classroom to online [5], [6]. A meta-analysis study comparing fully-online, face-to-face, and blended instruction reveals that the blended approach is more effective than others [7]. This result is further supported by long term studies across multiple disciplines at the authors' institution. The analysis shows that the blended approach replacing face-to-face instruction with online results in greater student success rates and enhanced student satisfaction when compared to traditional face-to-face instruction [1], [3].

Specifically, in the STEM field, studies have also shown that blended courses outperform traditional face-to-face courses. For example, the implementation of a blended engineering master's program in Spain not only increased enrollment, but also resulted in increased students' satisfaction, interaction with instructors, and learning performance [8]. The blended approach has been utilized in large-size engineering classes and the results have shown that students were more satisfied and that they believe they had more opportunities to apply their knowledge [2], [4]. Similarly, when the blended approach was used in a biology class, the findings showed that students learned deeper and their grades were better than those learning in the traditional classroom [9]. These studies indicate that blended approach better promotes independent learning and active learning as students are required to engage with course materials on their own online before coming to class. Also, the blended classroom, equipped with discussion and communication tools, further promotes social constructivism and discovery learning in science. Lastly, the use of technology and multimedia (graphics, video, animation, etc.) in these classes aid in the comprehension of the concepts.

An instructional technology common in blended, flipped classrooms is video lectures. Scagnoli et al. define a video lecture as "a video recording of a lecture, conference or presentation by a professor to introduce key concepts and additional information or examples to enhance students' learning" [10]. Video lectures vary in production methods and software [11]. The most common ones include (1) converting static slides with voice-over, (2) screencasting of instructor's activities on a computer's screen, (3) instructor drawing freehand on a digital tablet (Khan Academy style), (4) lecture-captured video, and (5) studio-produced video. In online or blended classrooms, instructor-generated videos are believed to increase students' engagement due to at least two reasons. First, the instructor's videos increase the instructor's presence. Research has shown that the presence of instructors in online courses increases students' attention, motivation, and cognition [12]. Second, video is a superior content delivery tool that helps information processing because it includes multimedia (audio and visuals), instead of text alone [13]. Another key benefit of video lectures is that they enable self-paced learning as students can control how, how often, when, and where they watch the video.

Previous studies have shown that students have a positive attitude about the availability of video lectures in their courses and that video watching may positively be associated with learning performance. Comparing the course sections that had instructor-generated videos with those that did not, Draus et al. found that students in the sections with videos were more satisfied and engaged more in discussion forums [14]. Traphagan et al. reported that the availability of video lectures decreased in-class attendance, but students who were absent and watched the videos performed well in class. Studies that investigated MOOC courses presented similar results [15]. They reported that student achievement is associated with the number of videos watched [11], [16].

In an attempt to understand the impact of video lectures in an engineering blended class, Rogers (2018) provided video lectures (using Lightboard technology) in alternate lessons/weeks across two semesters. In the first semester, the videos were available for lessons 2, 4, 6, 8, 10, 12, and 14. In the second semester, a different set of video lectures were provided for lessons 3, 5, 7, 9, 11, and 13. After every lesson, the students were to complete a homework assignment. When comparing the scores of these two groups of students, the researcher found that the scores for lessons with the videos were higher than non-video lessons, but only slightly. The author concluded that while videos help students better learn the content, the link between the use of videos and student learning is still not strong. Since research like Rogers's is scarce, researchers remain critical of the link between video watching and student performance [10].

Currently, learning analytics is used to further examine whether video watching impacts learning performance. Learning analytics refers to the data obtained from learning management systems or video platforms. Learning analytics offers data that may not be acquired by students' self-report. For example, using the data from a video platform across six semesters, Garrick was able to observe students in an engineering class on when they watch the videos, how often, where, and using what devices [17]. The researcher reported that students tended to watch the video lectures the evening before or the morning of the class. Some students watched the videos again before the tests. In another study by Brozina et al., learning analytics from an LMS showed that students who gained an A grade visited the online course consistently throughout the weeks while students who gained lower grades visited the course mostly the day when the assignments were due [18]. Yoon et al. (2021) used video learning analytics to better understand patterns of behavior and they were able to identify active and passive learners from the data. Learning analytics increasingly allows us to observe students' behavior in online courses and can be considered as another indicator of their success [19].

This study examines students' behavior online, especially video lecture viewing, and its effect on their performance. It utilizes learning analytics available from the video-hosting platform of Panopto. Since instructor-created videos are an integral component of a blended course, a generalized deduction is that the greater the engagement of a student in the online component, the better the performance of the student in the course. Previous studies have mostly focused on cumulative data analysis with regards to video views, video watch times, or course grades. While cumulative data provide good insights, examining each student's behavior and performance will better inform us of the relationship between lecture viewing and students' performance. Student satisfaction on the blended course delivery is also gauged through IRB-approved end-of-the-semester surveys. The specific research questions investigated in this study are the following:

- Does student online course (video watching) behavior correlate to student success in a high-enrollment advanced engineering course taught in the blended format?
- What effect does a blended instructional format have on student learning and satisfaction in a high-enrollment advanced engineering course?

2. Methods

2a. Study Design: Course Description

The Introduction to Vibrations and Control course examined in this study is an upper-level advanced undergraduate course in engineering. The course is a required course for all students majoring in mechanical and aerospace engineering at the authors' University. Typically, the students are at the end of their junior year or are at the beginning of their senior year when taking this course. The course enrollment varies from 250 to 275 students in each semester. The first half of the course introduces students to the fundamentals of free and forced vibration analysis of one degree of freedom systems and on free vibration analysis of two degrees of freedom systems. The second part of the course introduces concepts on dynamic response, feedback control analysis, system identification, and classical PID and root-locus control design techniques. The course learning outcome aligns with the Accreditation Board for Engineering and Technology (ABET) criterion that emphasizes a student's ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

2b. Study Design: Course Transformation

The blended course transformation took place over a six-month period. In the blended modality, 30% of the weekly course content was delivered through online lecture videos, while the remaining 70% of the content was delivered through in-class face-to-face lectures and activities. The students attended one weekly 110-minute in-class session in the blended class as opposed to three 50-minute weekly sessions that are standard in a regular face-to-face class. The course content was broken down into weekly modules, organized in the leaning management system of Canvas. In each weekly module, the instructor posted one to two online lecture videos with a total watch time ranging from 45 to 60 min at the beginning of each week. The students were encouraged to watch the lecture videos before the face-to-face sessions through weekly reminder announcements at the beginning of each week. The lecture videos were mostly recorded using the annotation tool and the recording feature in PowerPoint and some cases using the screencasting software Camtasia. A total of 25 lecture videos were created for the online content that were distinct from the in-class lectures. The videos were hosted using the platform Panopto which aided the authors in capturing detailed students' video analytics. Figure 1 shows an example video from the course. The in-class sessions consisted mostly of problem-solving sessions with a brief 20 to 25-minute review of the weekly concepts at the beginning of the lecture. Since both Vibrations and Controls are heavily mathematical fields involving many theories and equations, a brief review was done at the beginning of each class to quickly re-iterate the concepts that were discussed through derivations and other details in the weekly lecture videos. The students were also engaged in class participation quizzes during the in-class instruction to check student understanding of the content covered through lecture videos. The materials covered in the face-to-face sessions were posted as post-class notes. Weekly homework assignments were given out to the students to gain mastery on each topic.

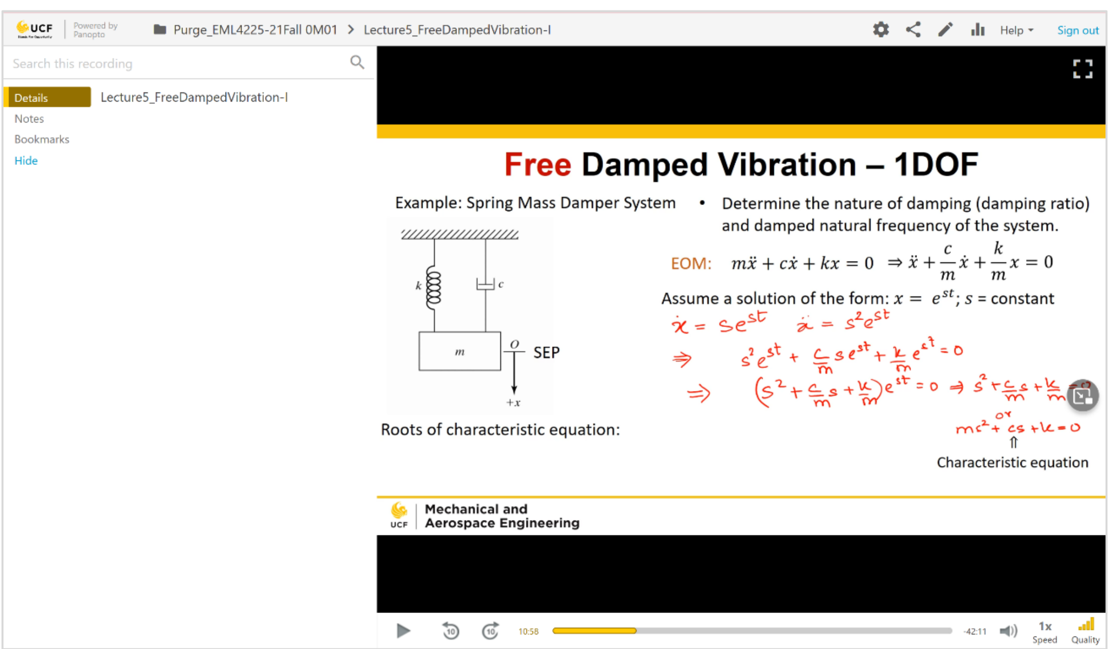

Figure 1: A snapshot of a lecture video prepared for the blended class and hosted through the Panopto platform

2b. Study Design: Course Assessment

As mentioned earlier, this research study was designed to examine the correlation of student online behavior to student performance and success, and student satisfaction in a high enrollment blended course. To investigate the first research question which evaluates students' lecture viewing behavior on student performance, student video watching analytics was obtained from Panopto [20]. For this paper, we examined the overall data for the instructional content videos from Panopto to determine whether students' overall grade in the course was related to their viewing behavior. Data was downloaded from Panopto and merged with the grade book data to allow for a dataset that integrated student engagement with the videos with their course performance. Analysis of variance (ANOVA) was used to test whether there was a significant difference in student engagement and viewing behavior with content videos by overall grade in the course. To examine the second research question on student satisfaction and learning in the blended format, a survey specifically designed by the researchers to evaluate the different components of the blended format was administered to the students at the end of the semester as an extra-credit assignment. The survey was approved through the Institutional Review Board (IRB) at the university and was administered through Canvas.

3. Results

3a. Student Engagement

Student engagement in the blended course was assessed using a two-fold approach. The first approach was through survey questions where students self-reported the number of times, they watched each lecture video The second approach used was the quantitative video analytics data captured from Panopto. The total number of videos views and downloads data for each student was extracted from Panopto to gauge the extent of online engagement for each student. Figure 2A shows the data from the survey about the frequency of video views. About one-half of the class (51%) reported that they watched the lecture videos only once, while 30% of the class reported that they watched the videos twice, and 16% of the class reported that they watched the videos three, four, or more times. Figure 2B shows the Panopto analytics data on the total number of video views and downloads per student for all 25 videos. Approximately, 6% of the class viewed the videos more than 75 or 100 times. Fifteen percent of the class viewed the videos 51 to 75 times, 42% of the class viewed the videos 25 to 50 times, while 38% of the class viewed them less than 25 times. The cumulative number of video views for the entire class was 9068.

If the data in Figure 2B is extrapolated and compared with the frequency data in Figure 2A collected from the survey using the total number of lecture videos (25), then the Panopto analytics data suggests that about 6% of the class viewed them three, four, or more times, 15% of the class viewed them two or more times, 42% viewed them once or more, while 38% viewed once or less than once. The extrapolated version of the analytics data captured through Panopto suggests that student engagement as expressed in terms of frequency of video views is reasonably good with greater than 60% of the class engaging in watching the lecture videos at least once or more. This extrapolated version of the data is slightly lower than the survey data reported by the students. This is expected since the extrapolation assumed that students with total views greater than 25 (the number of videos) watched all posted videos at least once. Additionally, the analytics data included a larger data set, that is from all 273 students enrolled in the class, while the survey data was collected from a slightly smaller data set, which included the number of students who participated in the survey.

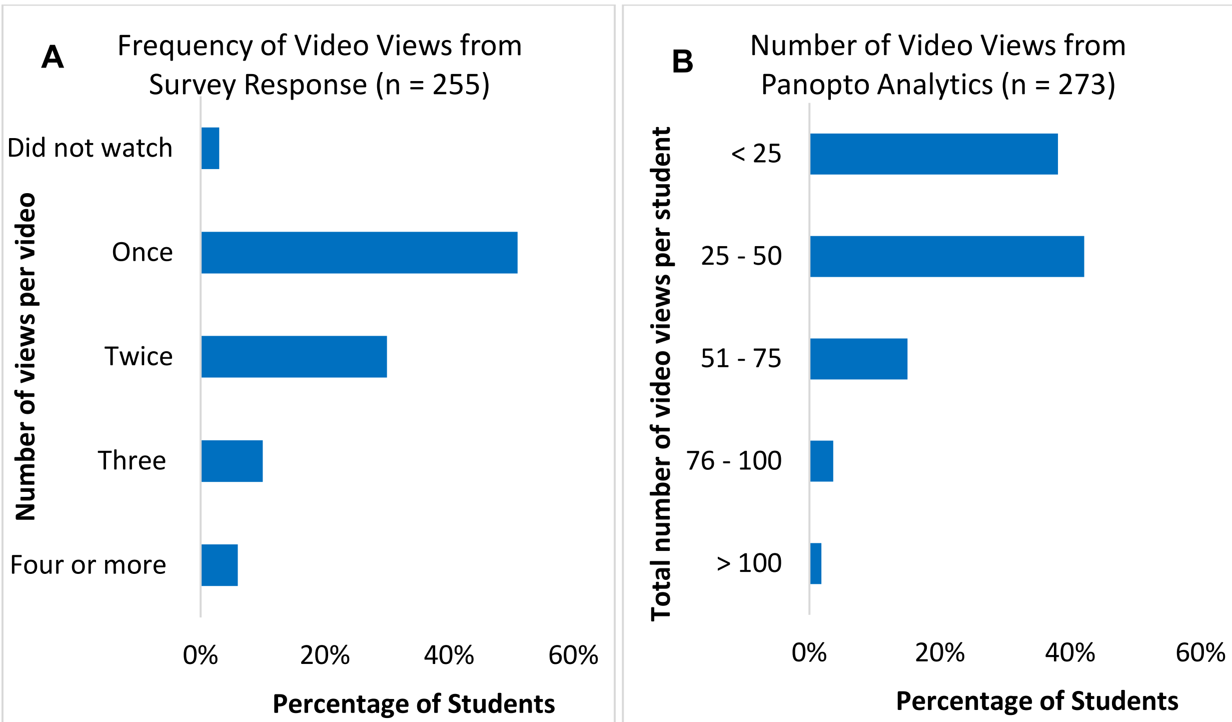

Figure 2: Video usage data obtained through (A) student survey response and (B) Panopto analytics

3b. Student Success to Engagement Correlation

Panopto analytics data provides overall information on student engagement with all course videos including overall views and downloads, overall minutes delivered, and average minutes delivered. Table 1 presents the means and standard deviations for the overall video views and downloads, overall minutes viewed, and the average minutes per download or view for the students and correlates it with the letter grade (A, B, C, D or F) obtained by the students in the class. The "views and downloads" in the table denote the number of video views and downloads across all viewed content and include partial video views. The "minutes delivered" denote the number of minutes viewed and downloaded combined for the viewed content while the "average minutes delivered" include total minutes delivered, divided by the number of views and downloads. These data were captured automatically by Panopto as students interacted with the videos stored on the platform. A consistent trend is evident in Table 1, indicating that students with higher grades were more engaged with the lecture videos. One deviation that appears is students who earned an F grade who had higher averages in all three metrics than those who earned D grades. Six students earned Ds and 10 earned Fs in the course, representing 6% of the total course enrollment.

Table 1. Average Student Video Viewing and Minutes Watched by Overall Course Grades

Letter Grade	**A (N=92)**		**B (N=101)**		**C (N= 56)**		**D (N = 6)**		**F (N= 10)**	
	M	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**
Views & Downloads*	42.97	21.49	31.89	22.00	26.07	19.79	9.77	11.93	11.00	13.65
Overall Minutes*	647.76	291.07	470.47	316.71	377.25	352.14	146.62	263.16	173.33	279.52
Average Minutes	16.06	6.67	14.45	6.72	13.56	7.76	9.89	6.12	12.51	8.35

*p<.01

One-way ANOVA analyses indicated a significant difference across grades for views and downloads, $F(4,260)=11.40$, $p<.001$; $\eta^2=.15$, and overall minutes, $F(4, 260)=12.05$, $p<.001$, $\eta^2=.16$. Tukey's post hoc analyses indicated that views and downloads were significantly higher ($p<.01$) for students earning A grades than those earning any other grade. No other comparisons were significant. For this research, we examined only the overall Panopto analytics. Future research will examine the impact of specific videos on exams.

3c. Student Perception and Student Satisfaction

The effectiveness of the blended instructional modality in improving the student learning process in Vibrations and Controls was assessed through the IRB-approved online survey administered at the end of the semester. The survey served as an indirect assessment tool for the investigators and aided in gauging student perceptions on the effectiveness of the lecture videos in the blended course. Approximately, 255 (95%) of the 269 students enrolled in the class participated in this survey. About 70% of the students in the class were mechanical engineering majors and the remaining 30% were aerospace majors. Student survey responses were measured using a 5-point Likert scale ranging from "strongly agree" to "strongly disagree".

Figure 3 shows the survey responses of the students to questions such as the effectiveness of the videos in improving their understanding of key concepts, problem-solving ability, overall learning, and in improving their confidence in getting good grades. As observed in Figure 3, 86-89% of the students taking the survey discerned that the lecture videos in the blended class improved their learning process in the course, while 76% of the students reported that the videos increased their confidence in achieving good grades in the class. The results in Figure 3 corroborate the fact that the students perceive the lecture video-based blended instruction as an effective way to learn course materials. These results are consistent with data reported by similar studies conducted on lecture video-based blended learning in engineering courses [2], [21].

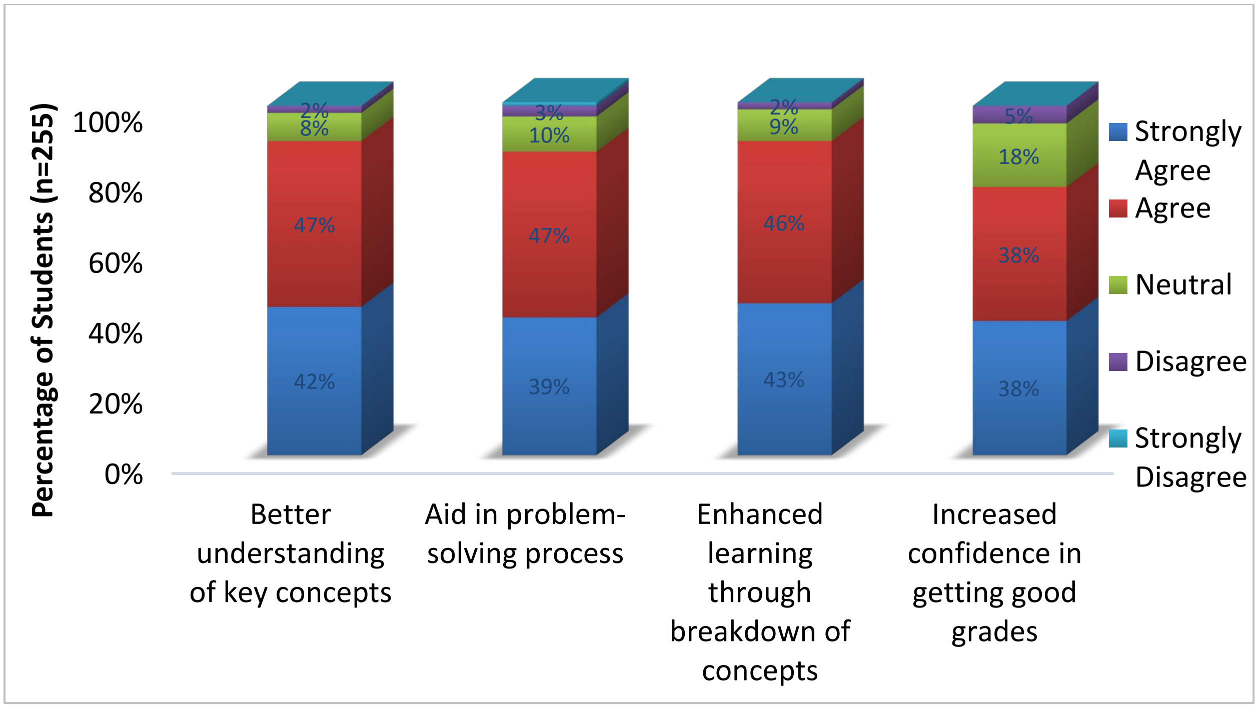

Figure 3: Student perceptions on the effectiveness of the lecture videos in the blended course

Student satisfaction and student attitude toward the blended course were also gauged through the survey questions. The students were asked about their overall satisfaction with the blended course delivery and their preferred future delivery format for this course in a no-pandemic scenario. Student survey responses to the above questions are evident in Figure 4. As observed in Figure 4A, 81% of the students reported that they were "very satisfied to satisfied" with the way the course was currently structured and delivered. Fifteen percent of the students remained neutral and the remaining 4% of the class were not satisfied with the course delivery. For the preferred course format question, 84% of the students favored some form of a blended course delivery over a face-to-face course in future semesters if there was no-pandemic as seen in Figure 4B. Most students preferred a 50:50 online to in-class content over the current format of the class which consists of 30:70 online to in-class content.

Student satisfaction on the blended course was also examined through open-ended questions embedded in the survey. In response to the open-ended question on what students enjoyed most in the blended course, a large fraction of the students reported that they appreciated the flexibility and accessibility aspects of the blended course, a moderate fraction of the students reported that they favored the self-regulated learning aspect of the course or the course resources made available in the blended modality, while a smaller fraction of the students reported that they felt more prepared in the blended format or appreciated the lesser commute in the blended format. In response to the least enjoyable aspects of the blended course, many students did not favor the length and number of videos and a small fraction of the students did not favor the exam delivery method.

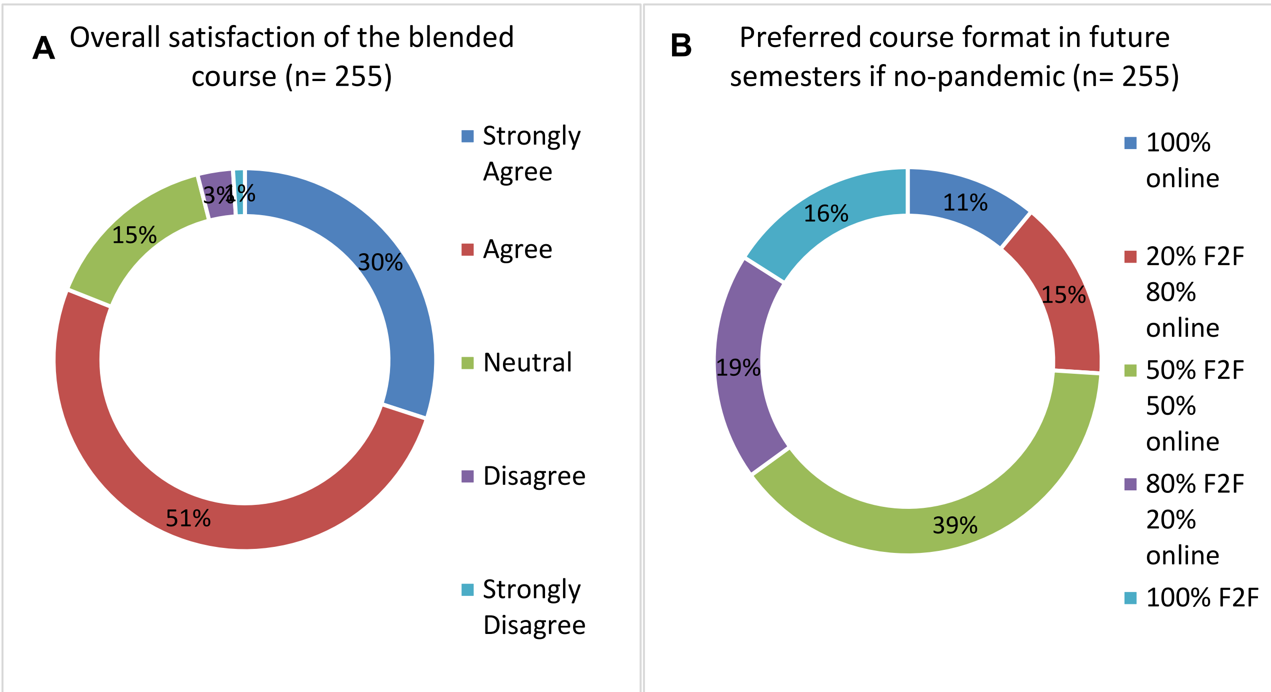

Figure 4: Student satisfaction and attitude towards the blended course.

4. Discussion and Conclusion

The results of implementing a blended instructional modality in teaching Vibrations and Controls in a high enrollment class are positive. Blended modality was previously implemented by the authors in another foundation engineering course with good outcomes. As a result, the idea was extended into an advanced course in the curriculum. In the current study, approximately 30 to 40% of the course content was delivered through 25 online lecture videos, while the remaining content was taught in a face-to-face format. Student satisfaction and student engagement through video-viewing, and the correlation of student engagement to course performance were examined through surveys and learning analytics data from the video hosting platform Panopto. Overall student satisfaction and student perception of the effectiveness of the blended course were positive from the survey results. More than 80% of the students taking the survey reported that they were satisfied with the blended course delivery format, while 76 to 89% of the students reported that the lecture videos helped them in learning the course content. Student engagement data as obtained from Panopto learning analytics indicated a good extent of student engagement with 61% of the class viewing the videos more than once. Course performance data as observed through letter grades for the students were correlated with their video engagement data to analyze deeply the impact of the videos on student learning and course success. Panopto analytics indicated a consistent correlation between the overall number of video views and downloads, the overall minutes viewed, and the course letter grade obtained by the students. Statistically significant differences were observed in the lecture viewing behavior for the “very good to excellent" group of students in the course who scored an A in the course. The preliminary results presented in this study are promising and motivate the authors to continue examining student engagement and student success in blended courses.

In future studies, a more detailed approach will be taken in correlating student engagement to student success. Factors such as the time spent, the timing of video usage, the number of views for specific videos will be examined and correlated to student performance in homework assignments and exams that test concepts covered in those topics. The results of this study and previous studies by the authors suggest that the blended instructional modality is a robust pedagogical approach that can yield positive learning outcomes in students when implemented in high enrollment engineering courses.

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