Student Video Viewing Habits in an Online Mechanics of Materials Engineering Course

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Abstract—The paper investigated video viewing habits of students in a sophomore-level, online Mechanics of Materials (MoM) course offered in Spring 2017, and how those habits affected student course grades. Data on student engagement, video engagement, and number of views were collected from a MoM course through a learning management system. The data was compared with video length, video content, and video type. Student viewing habits were the focus of the study. It was determined that student engagement decreased over the semester, video content affected video engagement or total views, and viewing rate fluctuated depending on the exam. Furthermore, an increase in student engagement and total views tended to coincide with improved student grades. While videos are an effective means of improving student course grades, changes could improve videos and increase engagement.

Keywords—hybrid classroom, online videos, higher education, Mechanics of Materials, engineering education

1 Terminology

Student engagement represents the percentage of time students viewed new content in a video. Viewing an entire video would result in 100% engagement. (If a student watched the first 3 min and the last 4 min of a 10-min video, student engagement would be 70%. Videos not viewed were excluded in the metrics to ensure accurate engagement numbers. If a student could have watched four videos and chose to watch 100% of three, and 0% of one, student engagement would be 100%. This was done to create a more accurate measure of how much of the videos students watched.)

Video engagement represents the average engagement of all students who chose to watch the video. (If four students watched any particular video with two having watched 75% of it and two having watched 25% of it, then the video engagement for the video would be 50%. Students who cehose not to watch any particular video were removed from the corresponding video engagement metric to ensure an accurate measurement of engagement. If four students could have watched a video, and three had 100% engagement and one had 0% engagement, then the video engagement for the video would be 100%.)

A *View* represents occurrences when a single student watched more than 5% of a video. Students could have multiple views if 5% of the video was watched at separate times with at least a 15-min gap between viewings. When referring to specific videos, the total number of times a given video was viewed is that video's total views. (Total views can also be broken down when referring to points in a video. If a video was viewed a total of ten times, then had a total of ten views, but had only eight views in the first thirty seconds, then those thirty seconds had eight total views. As the view progressed, a student may have continued watching the video, stopped watching it, or skipped to later points. These changes could result in a different total number of views at different points within the video, but not affect the final total number of views for the video itself.)

2 Introduction

Online classes are becoming progressively more prevalent [2], so prevalent in fact, that there are entire universities dedicated to them [1]. There are now few traditional universities that do not offer classes in an online format [1]. Subsequently, it is vital to understand how students and online courses affect each other. Students enrolled in online classes often only interact with professors through online materials provided for them, and the quality and quantity of that information can influence how well students learn. Factors such as length, information density, and format of online material can have a significant impact on student learning.

This paper investigated how student-viewing habits of materials provided in a course affect course grades. Issues such as students viewing only parts of videos, choosing to focus on one form of a video over another, and engaging to various degrees in materials provided may have a significant impact on their final grade. Consequently, it is important to understand how students view videos, and to know of recommendations that will help them improve their performance.

3 Literature Review

Since 2005 a majority of universities have considered online classes a critical part of their education strategy [1]; thus, various studies have attempted to determine how to implement them, how to determine their effectiveness, and how students evaluate them. Online courses are presented in several forms ranging from recorded face-to-face lectures, to the Kahn Academy style in which instructors present videos that include slides and hand-written annotations [4]. It is essential that the characteristics of these courses and their videos be understood, as online courses have proven successful and will continue to be implemented. With this knowledge, instructors can ensure that the format they use will be highly effective.

Many studies have provided valuable information concerning online classes, finding that online classes help students learn complex concepts using multimedia resources [5]. Others have investigated student perceptions of online classes such as enjoyment of class structure and the effectiveness of teaching methods [7]. Meta-analysis has found what forms of online classes are most effective in instructing students, in addition to finding that online classes could equal or surpass traditional classrooms at teaching concepts [8].

The most common format developed for online teaching is the video lecture form [4]. These class-related videos have been analyzed to detect characteristic trends such as how instructors use videos and the most effective video style. While these videos are essential to online classes, they are also becoming essential to the hybrid class that utilizes videos along with face-to-face instruction [11]. It is vital to understand more about hybrid class videos and to ensure that the most effective format, the Kahn Academy style, improves student learning [4]. The effectiveness of videos depend on factors such as the individual lecture, video length, and the date of the video [3].

Video characteristics are not the only components that affect video engagement and view measurements: student viewing behaviors and perceptions are also factors. Student characteristics such as gender where women have higher total views, or students pre-course GPA where students with higher pre-course GPAs tend to have higher viewing rates, can correlate with student viewing habits [3]. It is also known that students use videos to supplement online face-to-face lectures in hybrid model classes [6]. Despite this, students who watch videos at a greater rate still tend to perform better in class [9]. Furthermore, students on average have a positive view of online lectures and believe online lectures help improve skills [7 and 9].

Information is limited despite these findings. Few studies have focused exclusively on undergraduate university online courses. Some studies have investigated the use of videos in hybrid-format courses, and several have studied Massive Open Online Classes (MOOCs) [3, 11, and 4]. Results from hybrid classes are not exclusively applicable to online classes, and the MOOCs' population is not well defined or controlled as they are open to the public in many instances, possibly resulting in a bias within the data and influencing results. These are not the only issues: many studies of online classes did so by comparing them to traditional classes, and thus, limited their scope [10].

Further research is needed for strictly online classes because of the limitations mentioned above with both classes themselves and how students use class videos. Since there is no indication that online classes will fall out of favor, it is vital they be as effective as possible. That means continuing to improve and experiment with the Lecture-Example format and presentation styles, as well as finding what best engages students and proves to be the most effective instruction methods.

The present study investigated student-viewing behaviors in an online Mechanics of Materials (MoM) university class. The study focused on student viewing behaviors and how those behaviors affected their course grade. The results of the study will provide information on student interaction with online courses that future instructors can use to plan courses. The findings could also help students improve their study habits and subsequently, their final grade. Two research questions for this study are: (1) How do the characteristics of online videos such as length, content, and format affect student viewing habits in an online Mechanics of Materials course, and (2) How are student viewing habits in an online Mechanics of Materials course indicative of their final course grade.

4 Methodology

A sophomore-level MoM class was structured to enable student class interaction to be done totally online. All information was delivered to students in the form of pre-recorded videos, PDFs of slides provided in lectures, and PDFs of example problems with solutions. The students (N=18) were provided lecture (N=36) and example (N=57) videos through Blackboard Learn, an online education platform. They were free to watch videos at their leisure with no restriction as to which videos could be watched or the number of times they could be re-watched. Students were provided with a schedule that recommended when to watch specific videos to help them keep up with the class, but there were no other viewing requirements, enabling students to work on their own schedules. The class was given weekly homework assignments through the Mastering Engineering platform (an online homework and assessment system) along with periodic assignments to be completed by hand and then scanned into Blackboard. The class included exams that followed University proctoring protocol to test student knowledge on a variety of topics. The class was structured into four segments, each having its own non-cumulative exam after a set number of lectures. The topics for each segment are listed in Table 1.

Table 1. Exam cycles and video distribution.

Exam Number	**1**	**2**	**3**	**4**
Video Number	1-21	22-53	54-71	72-93
Topic Range	1-8	9-18	19-27	28-37
Total Lecture Videos	9	10	9	10
Total Example Videos	12	22	9	12

The data used for this study was collected using the video learning management system Echo360 that obtained data on student viewing behaviors. This included student engagement, video engagement, total views per video, and the number of views by each student. The data were downloaded to a text file spread sheet format and subsequently analyzed. Videos were intended to reflect the content/subject requirements of the class and to provide instruction for assignments and test preparation. The material within the videos was based on the textbook, Mechanics of Materials by R. C. Hibbeler; 10th Edition. At the end of the course, when all video data had been collected, various trends and relationships within the data were analyzed.

There were two types of videos, lecture and example, and both were designed and choreographed to serve separate purposes. Lecture videos were created to teach concepts required for course materials, often including an introduction to concepts followed by equations and diagrams depicting new material. Example videos served as a supplement to lecture material and provided instruction on how to handle problems similar to that presented in homework and exams. Lecture videos used lecture-slide layouts that were digitally recorded and accompanied by the instructor's written and spoken commentary.

The sample's data collected and measured originated from students enrolled in a 15-week online MoM course in Spring 2017. Students represented a variety of nationalities, had various levels of academic success before taking the course, and represented several majors. They resided both on- and off campus, some out of state and some outside the United States. Although this required some students to take exams off-campus, all students took the same exam with certified proctors regardless of where they lived.

5 Results

5.1 Engagement and Total Viewing Trends Over the Semester

An analysis ensued to identify significant trends once all video viewing data were collected. This information was correlated with video characteristics to determine what might have affected student-viewing behaviors. Behaviors were subsequently analyzed to determine if viewing habits significantly affected final student grades.

Video engagements and cumulative views were recorded for each video and plotted, beginning with the first video students were expected to watch, to the last. A vertical gray line indicates the last video before each exam (Figure 1). The linear dotted trend line shows that average engagement lowered as the class progressed throughout the semester (Figure 1). The solid trend line that followed short-term trends (Figure 1) shows a steady decline in video engagement from the beginning of the semester to the period directly before exam 2. Subsequently, there was a short increase in video engagement through exam 3, followed by a decline as the semester came to an end.

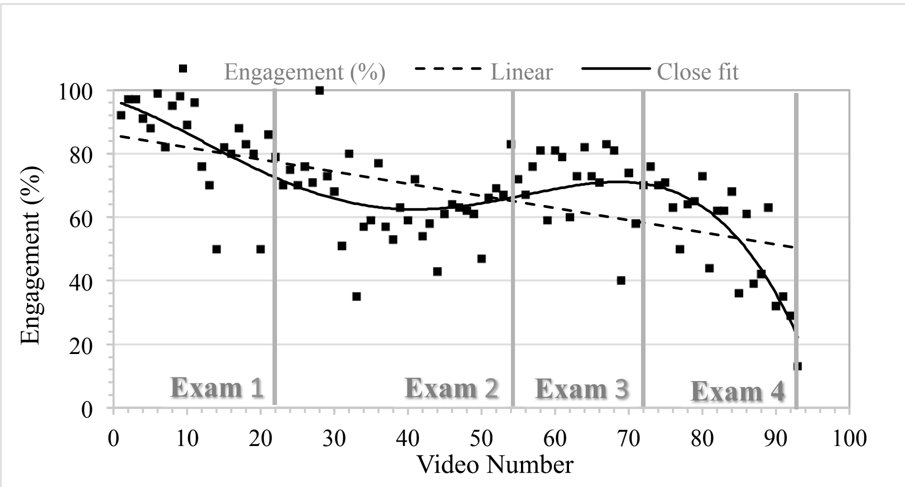

Fig. 1. Video Engagement plotted over chronological video order (vertical grey lines indicate last video before each exam).

Figure 2 shows total video views over the course of the semester. The solid black line shows several large spikes on video Numbers 22, 54, and 72: each is the first video after an exam. This material tends to be fundamental following an exam and results in a high view rate. Video Number 22 (Lecture 10) taught how to handle torsional shear stress and strain. Number 54 (Lecture 19) introduced students to deflection principles and also covered end support characteristics. Video Number 72 (Lecture 28) covered combined loading, a topic vital for almost all Mohr's Circle Lectures that followed.

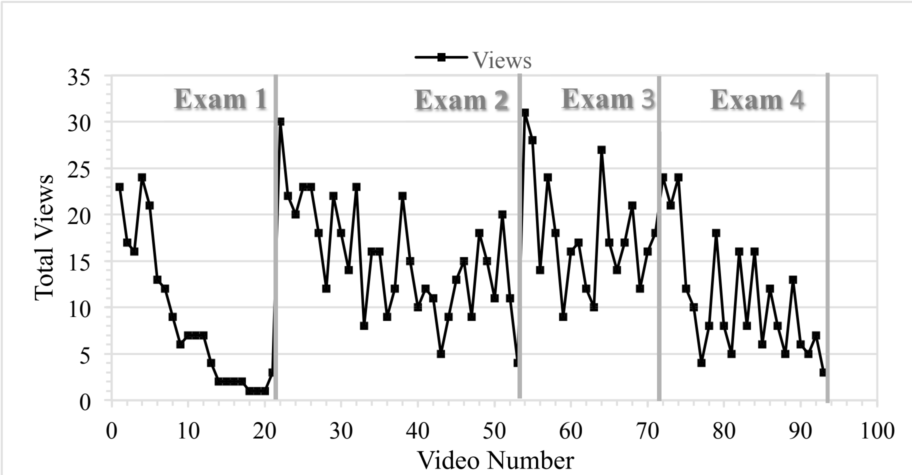

Fig. 2. Total Video Views plotted over chronological video order (vertical grey lines indicate last video before each exam).

5.2 Student Exam Viewing Trends

Total views for each student were compiled and compared against student exam grades for each separate exam after viewing trends for the semester were determined. As Figure 3 shows, there is a positive correlation between student viewing habits and their respective grades for each exam. Plots were broken into quadrants created by using averages of both total views and exam grades. Each quadrant, then, represents one student type. Quadrant 1 denotes students with above average total views and above average grades, which should be the case if students who watched videos more frequently correlated with improved grades. Quadrant 2 indicates students with below average total views and above average performance; these students managed to excel without needing to view an above average number of videos. Quadrant 3 signifies students who viewed the videos at a below average rate and performed below average on the exam, which would prove true if students watching fewer videos correlated with lower exam grades. Quadrant 4 indicates students who viewed at an above average rate and performed below average on the exam. If Quadrant 4 had been highly populated, it would have indicated that videos were not effective at improving student scores. Figure 3 shows a positive trend for all Exams between students having a higher total number of views and improved Exam scores.

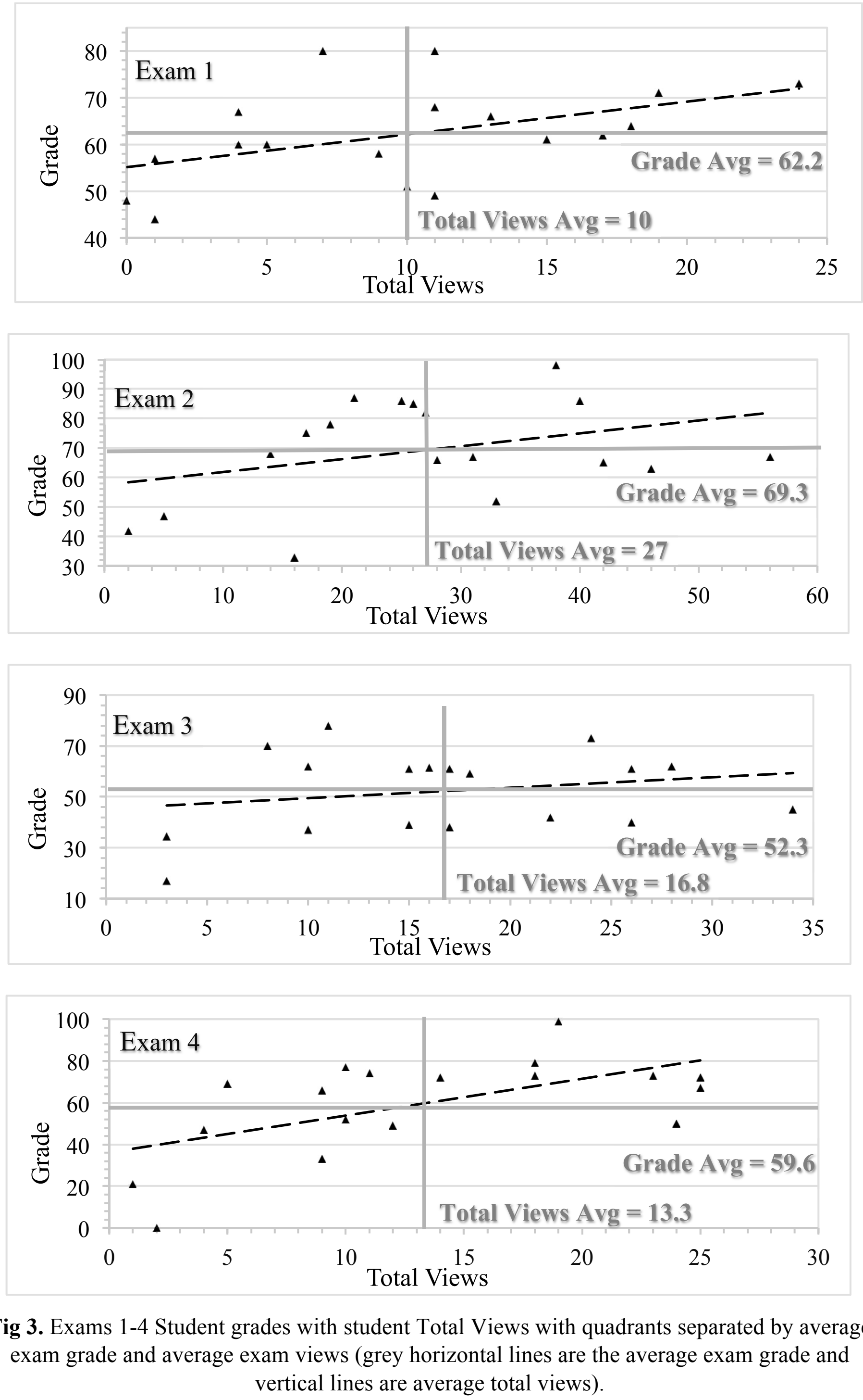

Fig 3. Exams 1-4 Student grades with student Total Views with quadrants separated by average exam grade and average exam views (grey horizontal lines are the average exam grade and vertical lines are average total views).

5.3 Video Characteristics and the Effects

Each video had components and characteristics that affected its video engagement and total views. Content was the video component that affected video engagement and total views the most. Content refers to topics presented in a particular video and how they were presented. Figure 4 shows total views at any time in the video and visual characteristics of video number 42, Lecture Topic 15: Shear & Moment Diagrams. The horizontal axis shows total views for each 30-second segment received. It could be that multiple students watched one segment or one student re-watched a segment multiple times. Each black vertical line indicates a slide transition on-screen. For several, there are noticeable upticks in total views immediately following the transition. This trend is indicative of students skipping through videos to find content they deem valuable. For transitions at the 180-s, 330-s, and 545-s marks, there were either necessary equations or valuable diagrams displayed on-screen; total views spikes occurred at these marks. The video player included a small preview feature, and spikes reveal that students used the preview feature to choose which moments to watch or to initiate pause. Thus, students could gather information without watching the entire video. Similar viewing patterns were seen in several other videos. Figure 5 shows another instance of students choosing to skip among video contents.

Consistent trends were evident when a video slide was displayed for a relatively long time. Several videos included only three to six slides. Any one of these slides could be left on-screen and explained for several minutes, and total views dropped the longer the slide was displayed--no matter what the content. Total views decreased during both mundane and vital topics. Figure 6 shows the result of leaving a slide up for an extended duration. A slide was brought up at the 90-s mark and was left up until the end of the lecture video. This slide covered Mohr's failure criterion of Brittle Material and contained three commonly used relations as well as a pair of diagrams to visualize Mohr's failure criterion. A decline can be observed as the video continued until only about half of the students were still watching it at the 300-s mark.

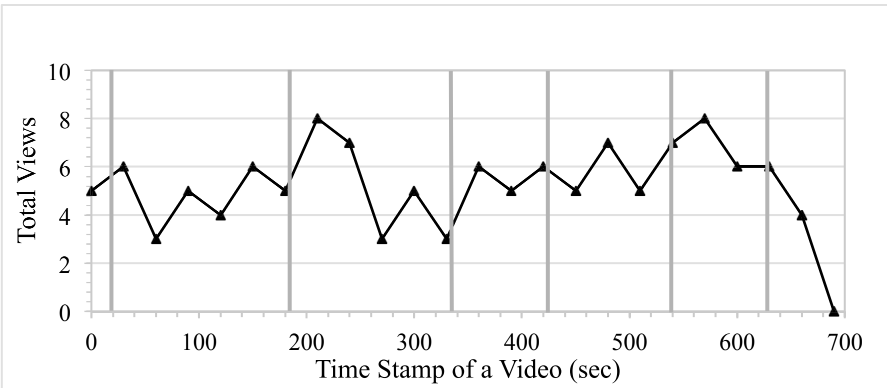

Fig. 4. Total Views vs. time plot for Lecture 15(Shear & Moment Diagrams). The grey vertical lines indicate when a slide changed.

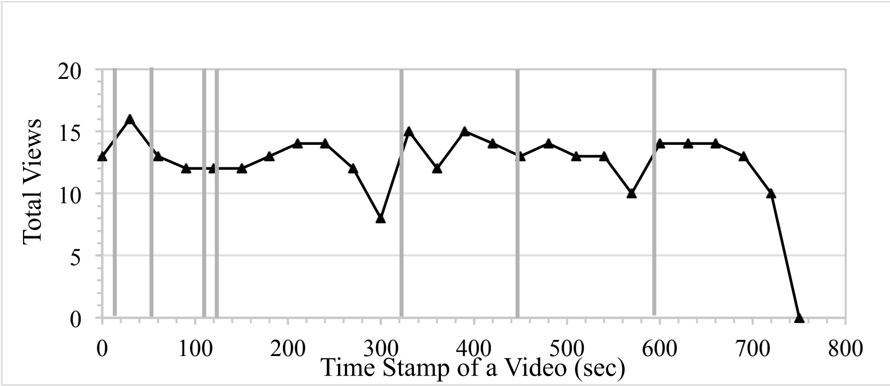

Fig. 5. Total Views vs. time plot for Lecture 10 (Torsional Shear Stress & Strain Lecture). The grey vertical lines indicate when a slide changed.

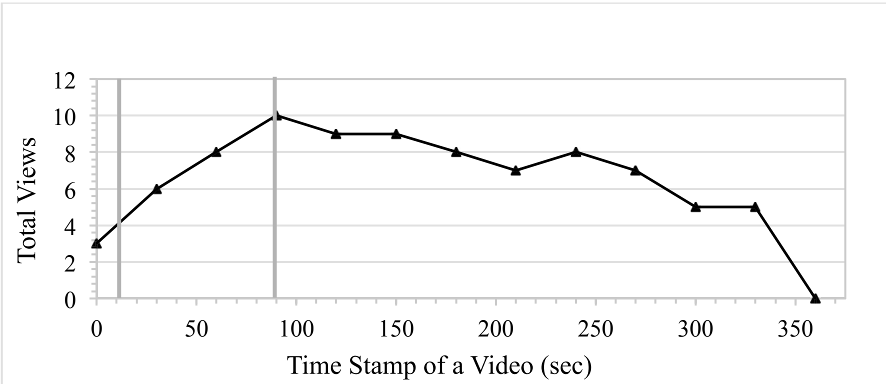

Fig. 6. Total Views vs. time plot for Lecture 35 (Failure of Brittle Materials) The grey vertical lines indicate when a slide changed.

Another video characteristic that affected video engagements and view measurements was the dense nature of some lecture slides. Four lecture topics had example videos with higher total views than the associated lecture video. A slide from video number 70, Topic 27: Principal Stresses; Max Shear, is an example of an overly dense slide. It contains equations, derivations, and figures, some of which physically overlap on-screen and in general make the slide appear overly cramped. It was dense enough that the instructor had to rewrite the equation in short form to provide clarity, removing the denominator of some equations to save space. In addition to its density, the general cramped appearance of the slide and others similar to it caused some students to turn to topical example slides in an attempt to learn the material not clearly explained in lecture slides. As a result, selected example videos show a larger total view count than associated lecture videos.

5.4 Video Types and Characteristics

Trends such as video viewing as a means of improving exam grades, students skipping portions of videos, and drops in the engagement for slides with long duration, occurred in both video types--lecture and example—and needed to be investigated and compared. First, the two video formats were compared to determine if students used them similarly: it was found that lecture videos were used at a higher rate. Table 2 shows that example videos averaged six fewer views and 10% lower video engagement than lecture videos.

Table 2. Lecture, Example video comparison.

Video Type	Total Videos	Average Video Engagement (%)	Average Views	Total Views
Example	57	63%	10.29	582
Lecture	36	73%	16.72	644

The two forms of videos were compared to see how each affected student viewing behavior and course grades. As Figure 7 shows, viewing either form of video tended to have a positive effect on final grades. This means that simply viewing the videos, lecture, or example yields a positive correlation. The rates at which student grades improved, whether lecture or example, were similar—within 2.5% error ((.3598-.3511) *100/.3598) of each other. Although the rates of course grade improvements were very similar for viewing both Lecture and Example videos, average views and ways in which students viewed videos were very different. While both video formats helped improve grades at similar rates, Example videos were viewed at a much lower rate than Lectures, indicating that students treated these videos differently while having a similar effect.

Another video characteristic was length. Lecture videos were sometimes as short as 2-min, with the longest lasting less than 20 min. There could be a large swing in video engagement and total views with such a disparity in video length. To determine this, both video engagement and total number of views were compared versus video length. Figure 8 shows video engagement for each video compared to length. This was separated into Lecture and Example videos to determine if the length of a video affected average student video engagement. Figure 8 shows a steady trend for Lecture videos and a slightly decreasing trend for Example videos. Figure 9 shows the total number of views for each video compared with the length of each individual video. This was separated into Lecture and Example videos and used to see if video length determined how many views a video received. Figure 9 shows and increasing trend for both Lecture and Example videos.

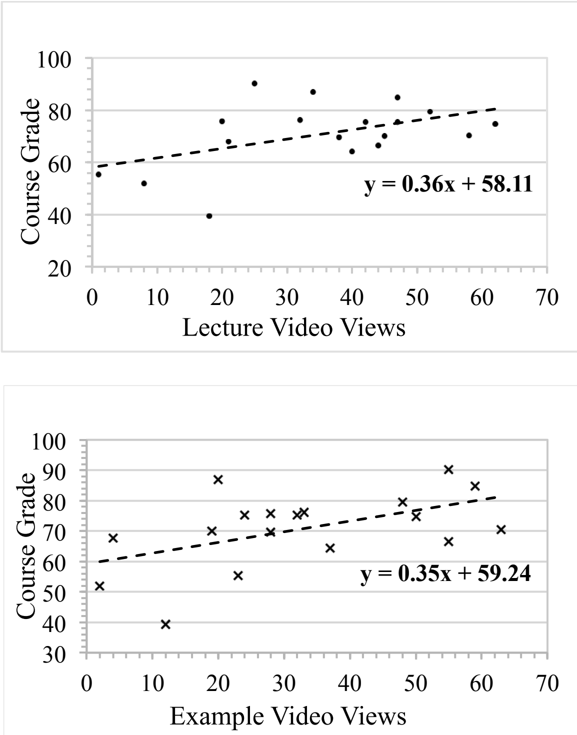

Fig. 7. Final course grades vs. Lecture and Example Video Views, including rate of academic improvement per view.

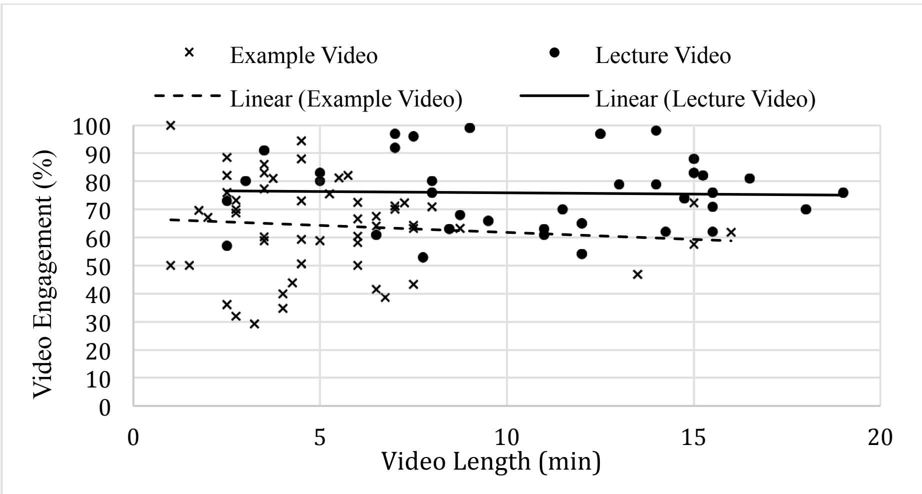

Fig. 8. Video Engagement vs. Video Length.

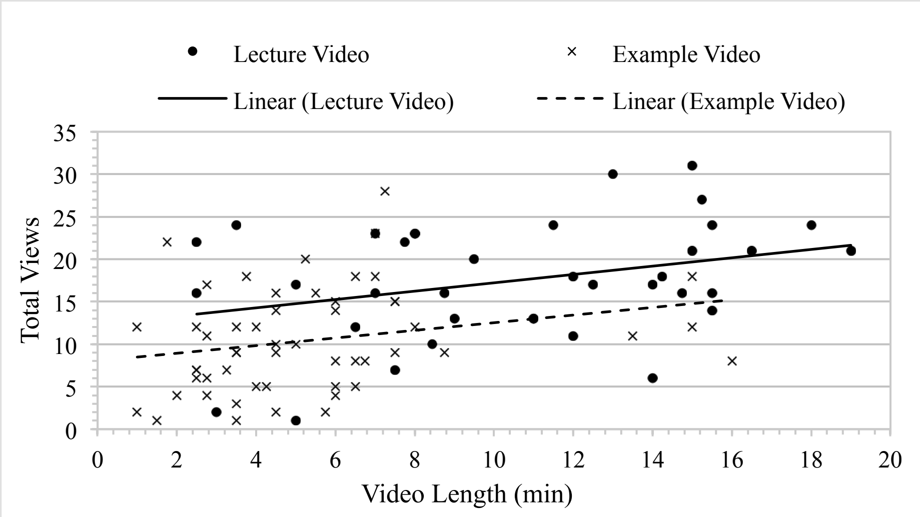

Fig. 9. Total Views vs. Video Length.

5.5 Residency Effect on Total Views & Student Engagement

Table 3 shows the distribution of student viewing habits based on their residency during the semester. Out of state or in-state residents had significantly higher rates of student engagement and total views than international students; however, as there were only three international students, the data is unreliable despite the three students having three of the four worst total views and student engagement measurements.

Table 3. Student viewership habits based on residency.

Viewership Type	International (*n*=3)	Out of State (*n*=7)	In-state (*n*=8)
Student Engagement	37.3%	62.2%	60.8%
Total Views	16.0	78.0	59.8

6 Discussion

6.1 Semester Video Engagement and Total View Trends

It was important to identify trends that affected how students interacted with online material over the course of the semester. This was vital because how students develop viewing habits and how those habits affect their course grade help instructors better understand how students interact with the class, specifically through provided videos.

Figure 1 plots video engagement for each video over the course of the semester and includes two trend lines. The dashed line shows that over the course of the semester video engagement decreased. This could be a result of students learning how to efficiently watch videos. That is, as students became familiar with video formats, they learned to find valuable material without having to watch longer portions. The solid trend line shows video engagement trends as they varied over the course: this curve was heavily influenced by exams. Steady drops occurred during exams 1, 2, and 4, while there was a considerable rise during exam 3. These trends may have to do with student perceptions of the difficulty and complexity of each exam that consequently required various levels of engagement.

The solid trend line in Figure 2 shows very large spikes after each Exam and a large variance in total views. This does not follow the pattern Figure 1 displayed over the course of the semester. These large spikes in total views occurred directly after each exam on the first video in the next exam cycle; the videos were often fundamental for the next exam and relied on multiple lectures. For example, video number 22, Topic 10: Torsional Shear Stress & Strain, is fundamental to Lecture Topics: 11, 12, and 13, Power Transmission, Angle of Twist (Determinate), and Angle of Twist (Indeterminate) tested in exam 2. As a result, students reviewed Topic 10 to improve their understanding of Topics 11, 12, and 13.

Many videos had considerably more total views than those in similar time frames, meaning that video number 38, Topic 14: Internal Shear and Moment Equations, had a high number of total views (22). But video number 42, Topic 15: Shear & Moment Diagrams, had a much lower number of total views (11) despite being a similar topic covered directly after Topic 14. This indicates that some viewing habits were based more on subject matter and less on class schedule. Some of these numbers increased as students re-watched the content later. Videos with the highest total views tended to involve more complex subjects which might have led to them being reviewed. Attributes in addition to complexity may have influenced high view counts. Students may have placed more value on videos containing very clear equations, diagrams, or tables of constants. Videos with these characteristics tended to have greater video engagement and total views than those viewed directly before or after them. That is, students may have seen the value in these equations and material in videos, as they were integral to homework, quizzes, and exams. This would cause students to actively seek out these resources.

6.2 Students Skipping Through Videos

It is important to determine where students found value to ensure that future videos are fully used by the students. If students did not watch portions of videos or skipped them entirely, then issues need to be addressed with both videos and student perception. A plot of student viewing habits over the course of a video was directly compared to videos themselves using timestamps to locate viewed content.

Several interesting observations were made. Students had a pronounced tendency to skip around within a video instead of watching it from start to finish. Figure 4 shows that some students selectively chose to only watch slide transitions accessed from the video preview screen. This may mean that students knew what parts of a video were valuable to them and accordingly sought out these segments. Thus, students tended to only watch portions they deemed valuable, often leaving other portions unwatched.

These spikes in total views within a single video show how dependent student viewing habits are on perceived information value. Students may believe they only need to view select frames such as those with equations/diagrams to fully gain all video information, thereby picking and choosing portions of a video to watch or pause on, and believe they have learned all the video has to offer. However, these students are forgoing a large portion of auditory commentary, perhaps not seeing it as necessary if slides contain most of the information. Students in the study focused on finding value in videos, meaning they were willing to skip through or ignore sections if they felt they understood the video fully, or that it was not worth learning. Consequently, if students are presented with the same visual for an extended period of time, their interest, engagement, and views may gradually decrease. Figure 6 shows that views did decrease if the same portion of a lecture or example video was displayed for an extended period of time. Most likely, students found the information they sought and were not interested in listening to additional commentary.

6.3 Lecture and Example Videos Characteristics

Two types of videos, lecture and example, were provided for complementary purposes, and students used them differently than intended. As shown in Table 2, examples averaged six fewer views and 10% lower video engagement than lecture videos. Thus, on average, students received less information from example videos than lecture videos, possibly because they might have thought that watching lecture videos was necessary to perform well in the course, and examples were only supplemental and necessary if they were struggling with a topic. Hence, students who felt they had a strong grasp of the subject would have no need to view example videos. Lower video engagement with example videos might also be explained by the availability of multiple example videos for each lecture video. Students might have watched only one of several examples to get necessary help, thus driving down the average.

Nevertheless, students did find value in example videos: students (N=18) viewed them 582 times out 1226 total views (47.5%). It seems they only needed select portions of example videos when they struggled with aspects of a problem instead of the entire process. They may also have been less likely to re-watch videos and tended to use source material to re-learn information. In other words, instead of re-watching example videos that may not have included needed information, students watched lecture videos that contained necessary equations and processes.

There were a few select lectures for which students chose to watch the complementary example videos at a greater rate, despite greater video engagement and higher total views for most lecture videos. It seems unusual that examples would have had greater video engagement and total views than lecture videos given that lectures were designed to be comprehensive and examples were designed to be very specific. However, once these specific videos were compared it became clear that students relied on examples due to the complexity and density of the complementary lecture videos. One such example is the slide from video number 70, Topic 27: Principal Stresses; Max Shear, an overly complex slide that could have caused issues for students struggling with the material. So much information was included on the slide that equation denominators were left out, potentially causing problems for struggling students. These lectures were so compressed that equations needed to be truncated for clarity; thus, students chose to watch examples because they may not have been able to get all of the information necessary from the lecture.

Even so, on average, students viewed lectures at a significantly higher rate than example videos. That students used lecture videos at a higher rate likely means they believed watching them would have a more positive impact on their course grade than watching example videos. However, Figure 7 shows that lecture and example videos have a similar correlation with respect to improving final student grades. A possible explanation is that students found the appropriate rate to watch both types of videos to gain equal value. On the other hand, students might not have been watching examples at a great enough rate, despite having equal effectiveness as lecture videos in improving the course grade. If the latter is correct, then students should be taught how each of these types of content is valuable in learning. The instructor can make a course-wide recommendation that, along with viewing the lecture video, it is highly recommended that students also view at least one example video if it is available; while lectures are necessary for learning concepts, examples are valuable for assignment completion and exam preparation.

6.4 Effect of Video Length on Video Engagement and Total Views

The length of a video itself is one of the simplest factors for determining how students use content. Students may tend to opt in or out of a video depending on its length for a variety of reasons. Time or activity constraints could cause them to watch shorter videos, or they may perceive the content of shorter videos as less valuable. If students put these limits on videos, they could miss information essential to the course. It may be necessary to change the length of videos. To determine if length was a factor affecting how students chose to watch videos, video lengths were compared to their total views, and then with average video engagement. These created Figures 8 and 9 and could be used to determine if the length of a video had any significant effect on video viewing. Figure 8 shows a steady level of engagement for Lecture videos and a slightly decreasing level for Example videos. Figure 9 shows and increasing trend for both Lecture and Example videos.

There is a need to ensure balance between content and length in videos even though length did not significantly affect video engagement or total views of lecture videos. The increasing level of Lecture views seen in Figure 9 could be a result of longer videos having more content that needs review. The reason for the consistent engagement for Lecture videos could be due to the information density of the videos themselves. These videos compressed full-length lectures into shorter videos ranging from 3-min to approximately 20-min. Thus, the videos were very dense and students saw continual value whether they were 3- or 20-min long. Students may watch what they consider of value; however, if extended periods of silence and/or off-topic discussion occur, it can lower engagement. That phenomenon may explain why example videos have lower video engagement on average (Figure 8, Table 2); students often use examples to solve a step in a problem, not the entire problem. This means they only need to view small sections of a video to get information they consider valuable. For example, students might view a single frame of a video that contains all the information they need to solve a problem.

6.5 High View Count Videos

As shown in Table 4, total views varied greatly between all videos provided for students--some having few, and the peak having 31 total views, with several students viewing them multiple times. Select videos may have had very high view numbers because of inherent content complexity requiring multiple re-watches. These videos might also have contained content with which students had no previous experience. After investigating exam questions presented to the students throughout the semester, it became apparent that for three of the four exams there was material from one lecture that was present in the majority of the three to four questions asked. Meaning that exams 1, 2, and 4 relied heavily on material from one lecture that other lectures built upon. The cause of this is likely related to how fundamental these subjects were for the rest of the material presented in that exam cycle. Because this video would be needed to properly understand subsequent lectures, the first lecture might have been re-watched often to clarify later videos.

Table 4. A collection of videos with highest view counts throughout the semester.

Video Name	Total Views	Topic No.	Video No.
Deflection by Integration	31	19	54
Torsional Shear Stress & Strain	30	10	22
Deflection by Integration (E.g. 1)	28	19	55
Buckling	27	22	64
Combined Loading	24	28	72

While it is logical to assume that several introductory lectures had high total views while students were becoming acclimated to the class, some lectures presented later in the semester had a significantly higher number of views than lectures directly leading up to, or directly following the introductory material. This includes videos such as number 22: Torsional Shear Stress & Strain, which details how shafts are twisted and react to torque, the basis for concepts of four or more other lecture videos. Other videos such as number 64: Buckling, which explains how slender rods react to axial forces includes vital diagrams for which students need to complete assignments to perform well on exams. Number 54: Deflection by Integration, which details how beams bend when subjected to forces and moments, contains information that is both vital for the diagrams presented, and for which a few other lectures heavily rely. These videos often needed to be re-watched to gain further understanding. Many of the same videos also contained valuable reference materials such as equations and diagrams that students used in their studies.

6.6 Exams and Grading

There was a notable disparity in Average Exam Grades for exam 3 when compared to the other exams (Table 5). There are a few possible explanations for the lower average third exam grade. It could be that the material presented was more difficult, but there is also a possibility that having an exam with no common subject between questions could be more difficult for students. With the other three exams, students had certain topics that were present in the majority of questions, whereas for exam 3, each of the three questions relied on non-connecting topics. The topic for exam 1 was Deformation: Normal & Shear Strain, for exam 2 it was Torsional shear stress & strain, and for exam 4 it was Combined Loading. While all questions in each exam were significantly different, the majority of questions in each of the three exams contained overlapping topics. However, the topics for exam 3 covered Beam Deflection by Superposition and Integration, Buckling, and State of Stress. There was very little topic overlap within the question, resulting in a larger variety of topics for which students needed to be prepared.

Table 5. Average exam grade for each exam.

Exam Number	1	2	3	4
Average Exam Grade (%)	62.2	69.3	52.3	59.6

6.7 Residency Effect on Total Views & Student Engagement

Another factor considered was how students' place of residency might affect their interaction with the course. It seems logical that residency should not affect success, as this was an online class requiring no physical interaction. Table 3 shows that International students engaged with videos on average 24% less than their Domestic counterparts. It also showed that International students averaged 44 fewer total views than students representing in-state residencies, and 62 fewer views than out of state US students over the course of the semester. This could be a result of distance that created a dis-connect between students and the course. It could also involve a language barrier, but this disparity was certainly affected by the small number of international students included in the study.

There was also a noticeable difference in the average number of total views between in-state and out of state students. The disparity could have been a result of students from out of state taking fewer classes. But a more likely explanation for the disparity is the small sample size with only three International students involved.

7 Recommendations

The data suggests several recommendations for instructors who will be teaching online classes using a video format. It is highly recommended that instructors provide both lecture videos covering the topic and some form of supplemental video to help with homework or test performance. This will help students more completely understand provided material, as any material misunderstood in lectures can be clarified in supplemental materials.

Another resource instructors could include is an example video addressing a question emanating from a homework assignment that came to the instructor's attention after the assigned due date. This could help students who struggled with the topic attain a direct solution to a difficult problem, and would also encourage students to utilize example videos more often, as some videos are not viewed at all.

It is also recommended that videos be structured to provide maximum value and motivate students to utilize them. Videos are information dense; hence, long periods of silence and repetitious information should be kept to a minimum. Additionally, visuals should change at regular intervals, and lessons should progress steadily and quickly to ensure that students will remain engaged and reduce skipping. Annotated slides overlapped with instructor commentary has proven to be exceptionally effective as well [4]. Striking a balance between density and clarity is vital for an effective video: structure of this nature helps clarify information for students.

8 Limitations

The most prominent limitation of the current study was the small sample size. Nevertheless, the sample rendered trends that are pronounced and consistent throughout the data; however, they might be significantly less prominent when applied to larger class formats.

The service used to record the data, video learning management system Echo360, was also a limitation, as it did not collect a large variety of metrics. For example, it did not provide dates when videos were viewed nor whether students reviewed them before exam dates. As a result, some metrics were either unavailable or unusable.

9 Conclusion

The purpose of this study was to investigate student-viewing habits in an online class, and to determine how those habits and video attributes affect student course grades. Data measuring student engagement, video engagement, and total views of the provided videos were used to understand how videos were watched, and to determine what characteristics of viewing were effective at improving student grades.

An investigation of viewing habits revealed how adaptable students are in their frequency of video viewing, and how engaged they are while doing it. Results show that even though video engagement declined steadily during the semester, students tended to adapt, depending on factors such as exam difficulty and the value of the material. Adaptation allowed students in this study to be better prepared for exams: improved student engagement and total views correlated with improved course grade. This improvement supports the contention that the lecture video format for online classes is an effective instructional method.

The second important trend noted was how the length and composition of a video affected student-viewing habits. While the length of a Lecture video had no effect on video engagement there was a noticeable trend in increasing total views. The other significant factor was how the composition of a video affected how students chose to watch it. If videos were too complicated, lacked visual change, or included portions with perceived minimal academic value, students shied away from, or skipped through them. Thus, videos should be designed for clarity, include relevant material, and be visually stimulating to improve student engagement and total views.

10 Future Studies

The present study was a comprehensive investigation into an online class and student viewing habits; however, the small student population employed in the study was a limitation when investigating trends. It is imperative in future studies that the viewing habits of students be investigated in the event an online class relies on the same video format as the one in this study. The results could be supported or negated by using this study as a general compass.

It is also important that the characteristics of videos themselves be properly investigated to determine how to present necessary information most effectively. An optimal lecture video for relaying information will help future instructors get information to their students. Length, content, and information density should be investigated with larger sample sizes to optimize the effectiveness of future videos. Many aspects of the class and the videos should also be correlated with student grades to find the strongest relationship. This allowed instructors to better understand what affects student grades and allows them to inform students on how to perform well in class.

Similar studies should consider some of the same trends but with full-length rather than condensed videos. Each video in this study consisted of an entire lecture condensed to an average of approximately 10 min. Comparing these compressed lecture videos to those not compressed could provide valuable information on both online and traditional classes. If it is found that compressed lecture videos engage students more and help them learn material better, then changes to both online and traditional classes could be implemented.

It is also vital to garner student perspectives on videos, as students are the ones who learn from them. Understanding their opinions regarding length, content, and density would be valuable when making engaging and effective videos. Student interviews that elicit their impressions of videos conducted at the end of a traditional as well as an online course could be valuable and help attain student opinions of online classes. Pairing qualitative data from interviews with quantitative data from studies such as this one will help provide a comprehensive understanding of student video viewing behaviors.

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