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Flipped Classroom Video Engagement for Generation Z Engineering Students

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Abstract

The diminishing attention span of students has been an increasing challenge for engineering educators, especially in technical modeling and design courses. Generation Z, or Gen-Z, is the cohort of individuals born between 1996-2010. Instructors must adapt their teaching methods to communicate and educate this new generation of college students who are 100% digitally native and are characterized as fast decision-makers and high-efficiency multi-taskers. One instructional strategy is the use of "flipped" classrooms, which reverse traditional learning environments by delivering content, often online, outside the classroom, while moving activities (e.g. homework) into the classroom. A flipped classroom teaching strategy was implemented in a pilot study for an industrial and systems engineering simulation course. Students were sorted into four cohorts based on when they chose to watch the videos: *Pre-activity, Post-activity, Pre-exam,* or *Never.* This research pilot project investigates the number of students who watched the videos, their respective video coverage (percentage of the total video length that was watched), and the learning outcomes for each cohort. We found a significant increase in the number of students (average increase of 11 students) who watched the videos in the *Pre-exam* cohort when compared to the *Pre-* and *Post-activity* cohorts.

Keywords
Flipped classroom; engineering education; Generation Z; video engagement; learning outcomes

1. Introduction
An increasing challenge for engineering educators has been the decline of students' attention span. Today's engineering students are from Generation Z (Gen-Z) which is the cohort of individuals born 1996-2010 [1]. Gen-Z students are digital natives and demand immediate access to information [2]. They are high-efficiency multi-taskers with 8-second attention spans, typically splitting their focus across 5 screens (e.g. phone, computer, tablet, etc.) at once [3]. In comparison, the Millennial generation (born 1981-1995) has 12-second attention spans and utilizes 3 screens simultaneously. The 8-second attention span of Gen-Z students expect easy and entertaining access to more information, and they have learned to rapidly filter out what does not interest or bring value to them [4]. These students are the first students to enter college as digital natives and therefore these students perceive technology as a way of life, rather than a learning tool. In this setting, instructors are merely assistants to their online learning practices. Gen-Z students utilize technology to deal with the stressors of life by engaging in online video and social media platforms (e.g. YouTube, Instagram) [5]. They are also dominant consumers of online learning methods using these same platforms where popular videos average under 10 minutes in length. In fact, the majority of Gen-Z consider YouTube their #1 source for learning [6]. Consequently, traditional classroom lectures no longer provide enough engagement for Gen-Z students [7] and many are continuing to convert to "flipped" classrooms [8, 9].
Traditionally, students learn information in a classroom setting and are expected to complete difficult homework with little to no instructor help [10]. In flipped classrooms, content is delivered outside the classroom in online videos (e.g. pre-recorded lectures) for self-paced learning, and active-learning activities occur in the classroom to use class time as problem sessions to practice and apply knowledge with the instructor as an on-site resource. Pre-recorded lectures allow for a student to complete their learning at their own pace by pausing or rewinding at a part that may be confusing to them [11]. This intrapersonal learning is something that sets Gen-Z apart from the Millennials. Gen-Z students are attracted to the idea of being in control of the timing, pace, and environment in which they learn [12]. Flipped classrooms also change the traditional transfer of knowledge from a teacher-student model to a hyperconnected model where students learn from teachers as well as other students and the digital world [10]. Previously, research methods for engineering education were focused on Millennials. Therefore, learning spaces, including the classroom, are

currently built for these students. Now, Gen-Z students prefer choices between independent study or engagement in group learning [12].

The research objective of this paper is to understand how the flipped classroom teaching strategy performs in a software-intensive industrial and systems engineering course, and whether it is effective in engaging and educating Gen-Z students. Our data will show how many students are watching the videos during certain points in the semester and how each student performed on graded assignments. We will separate students into cohorts depending on when in the semester they engaged with the videos. In order to qualify for the cohort, the student must have watched 60% or more of the video. This is to ensure that the student was engaging enough with the video to learn part of the material. Certain videos also included graded quizzes to make them more interactive and to motivate the student to watch the videos by their scheduled due date. We will compare the video engagement of these videos to the videos that did not include quizzes to determine if the graded quizzes impacted student video engagement and grades. Section 2 describes the design of the pilot study and the cohort definitions. Section 3 presents the analysis results of video engagement and learning outcomes via quizzes and exams, with conclusions appearing in Section 4.

2. Methodology

A flipped classroom teaching strategy was implemented in a pilot study for the second half of an industrial and systems engineering simulation course with 53 students enrolled during the Spring 2019 semester. Course instructors converted the traditional lecture style into online videos. Topics covered during this period come from four chapters of the course textbook (chapters 5-8): i) advanced simulation modeling, output analysis of ii) steady-state and iii) terminating simulations, and iv) entity transfers. The course material is software intensive and recent former students have not found the traditional lecture style to be supportive of their learning needs [7]. Educational videos in a flipped classroom setting permit self-paced learning, which is appealing to Gen-Z students, especially in a software-intensive course where it is easy to miss a key step, syntax, or encounter an error that requires debugging.

In Spring 2019, the material was developed and delivered through online medium-length video lectures (30-50 minutes) to reflect the length of a regular lecture, but still permit self-paced learning. Class time with the instructor included small-group activities based on online video content. There was a total of 9 medium-length videos across chapters 5-8; 4 videos had no activity, 4 videos had non-graded multiple-choice quizzes, and 1 video had a graded multiple-choice quiz. **Table 1** shows the number of videos and video length. The video data reported which students had watched the videos, their respective video coverage (percentage of the total video length that was watched), and their in-video quiz results; additional data was collected on the final exam results for each chapter. Video logins enabled tracking of four cohorts of students also video coverage had to be >60% to qualify for a cohort: 1) *Pre-activity* cohort are those students who watched the videos by the assigned due date before any corresponding in-class activities occurred (tracked for Chapters 7 and 8 videos only); 2) *Post-activity* cohort are students who watched the videos by the due date of lab and/or homework assignments for the corresponding chapter; 3) *Pre-exam* cohort are students who watched the videos in preparation for the final exam; 4) *Never* cohort are students who never logged in to view that specific video or had video coverage <60%.

Table 1: Number of videos, video length, and defined label for each video chapter (Q next to the videos' label show the non-graded multiple-choice quiz and Q* graded multiple-choice quiz.)

Chapter	Video	Label	Length (Minutes)
5	1	5.1	0:38:24
	2	5.2	0:53:14
	3	5.3	0:48:24
	4	5.4Q	0:36:42
6	1	6.1Q	0:39:04
	2	6.2Q*	0:38:33
7	1	7.1	0:43:35

	2	7.2Q	0:38:30
8	1	8.1Q	0:32:36

3. Statistical Analysis

We now present a statistical analysis and the impact of the flipped classroom videos on students' grades. We analyze data for Spring 2019. A total of 53 students registered for the class. We investigate two statistical analysis on registered students. First, we present **Video Engagement** in two parts: 1) the number of students who watched the videos and 2) average video coverage. In the second analysis, we summarize the students' grades in two parts: 1) in-video quizzes and 2) the final exam.

3.1. Video Engagement

The first analysis for **Video Engagement** in Spring 2019 reports the number of students who watched the videos in the four cohorts of *Pre-activity*, *Post-activity*, *Pre-exam*, and *Never* shown in **Figure 1**. The *Pre-activity* data did not exist for chapters 5 and 6 as the selected activity only related to Chapter 7 and 8. Cohort size in Figure 1 shows cumulative summation. As an example, 21 students watched at least 60% of the video 8.1Q for *Pre-activity* cohort, 4 more students for *Post-activity* cohort, 17 more students for *Pre-exam* cohort, and only 11 students for *Never* cohort. The majority of students did watch at least 60% of the videos; our data indicated that between 42-51 students (average 46.5 students or 87.8%) watched the nine videos. There is a trending decrease in the number of students who watch the videos as the semester progresses. Intuitively, this means students have strong engagement when the videos are first introduced which decreases as more videos are released. In all videos, there were 2-11 students who did not watch at least 60% of the videos, thus falling into the *Never* cohort. Additionally, first five videos had a small but noticeable increase (e.g. 3-8 students or 5.6-15.1%) in the number of students who watched videos in preparation for the final exam (between *Post-activity* and *Pre-exam*); however, the increase was much more substantial near the end of the semester which are the next four videos (e.g. 16-22 students or 30.1%-41.5%). To our surprise, in Chapters 7-8, only 21-28 students (or 39.6-52.8%) watched the assigned videos prior to the lab activity; and only a few students (e.g. 3-4) watched it to complete the assigned homework. Thus, assigning videos in preparation for the lab was not enough motivation to get students to watch the videos. Thus, approximately half of the students later watched the final four videos while working on the semester project or to prepare for the final exam.

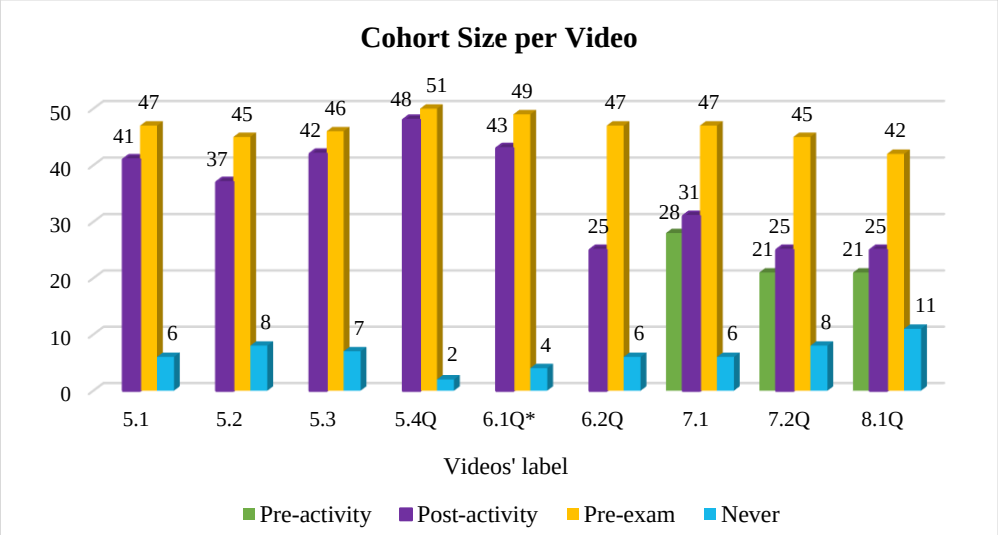
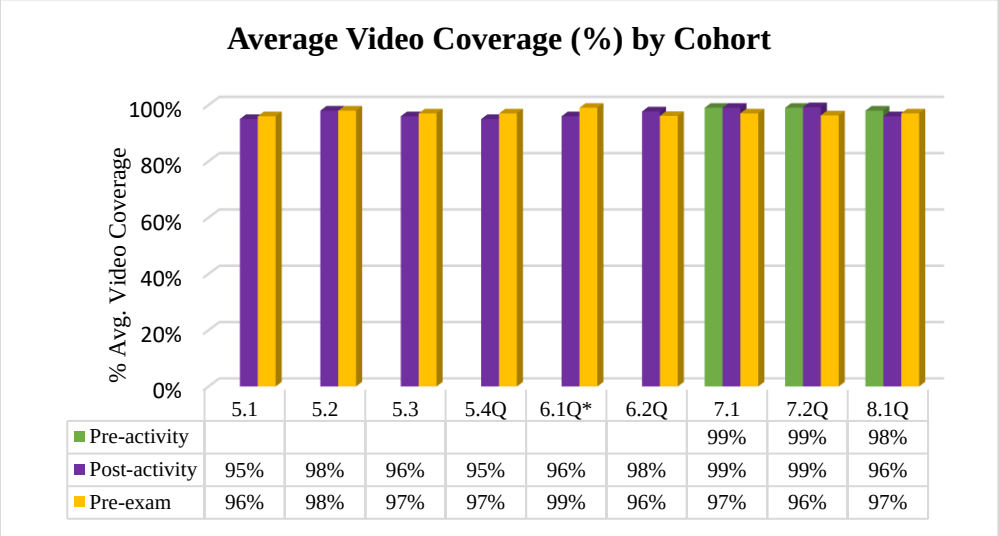


Figure 1: Number of students watched videos in four cohorts of (*Pre-activity*, *Post-activity*, *Pre-exam*, and *Never*)

The second analysis for **Video Engagement** shows the percentages of average video coverage for students who watched the videos more than our defined threshold of 60%. The results of these percentages are shown in **Figure 2**. Results show that there is not a significant increase in video coverage who watched the videos in the *Pre-exam* cohort when compared to the *Post-activity* cohort. Furthermore, the data shows that in-video multiple choice quizzes,

regardless of whether it is graded or not, does not increase video coverage. However, we can see, that most students watching, actually watched the full videos.



	5.1	5.2	5.3	5.4Q	6.1Q*	6.2Q	7.1	7.2Q	8.1Q
Pre-activity							99%	99%	98%
Post-activity	95%	98%	96%	95%	96%	98%	99%	99%	96%
Pre-exam	96%	98%	97%	97%	99%	96%	97%	96%	97%

Figure 2: Percentage of the video coverage in three cohorts of (*Pre-activity*, *Post-activity*, and *Pre-exam*)

3.2. Learning Outcomes

The first analysis for **Learning Outcomes** in Spring 2019 investigate relationships between quiz grades and video coverage. Only video 6.2Q* has a graded quiz, while the other four videos have a non-graded quiz. **Figure 3** shows the scatter plot of the % video coverage and video quiz grades. Linear regression lines for each quiz data set consists of finding the best-fitting straight line through the video quiz points. The linearly increasing lines indicate that those who watch more of the videos, receive higher quiz grades. Our next analysis will explore whether this also translates to better performance and learning outcomes on the exams. Finally, note that the graded quiz, 6.2Q* (green line), has a slightly steeper slope than others meaning that this relationship between coverage and grades is stronger; however, the difference is not significant and is similar in slope to 6.1Q.

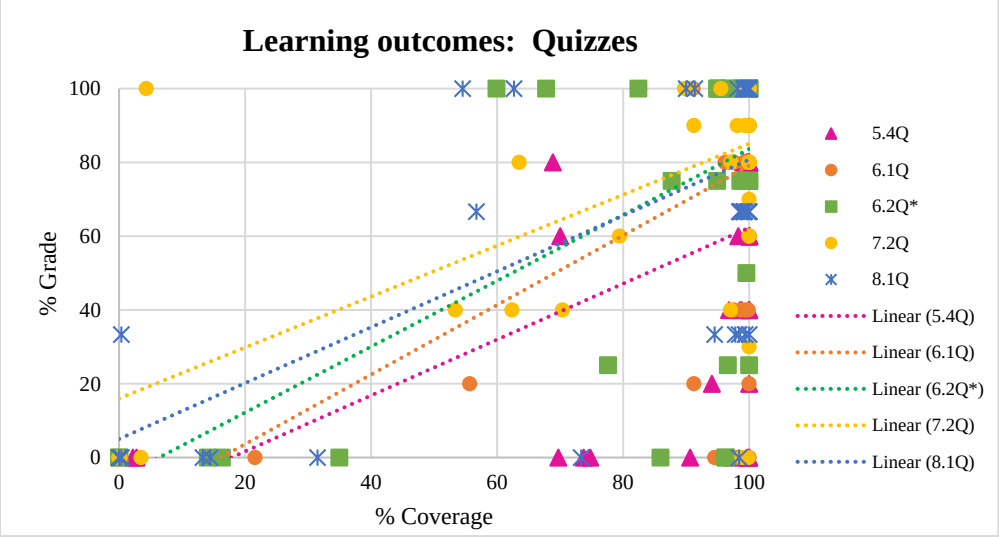


Figure 3: Learning Outcomes: % Coverage vs. % Grade for all 53 students

The second analysis for **Learning Outcomes** in Spring 2019 studies % average final exam grades by cohort for videos 6.2Q* and 8.1Q. **Figure 4** shows the results for the interactive and multiple-choice final exam questions specifically related to two videos (6.2Q* and 8.1Q). In this context, interactive means that the students had to modify the code for

a model and answer related questions. The cohort sizes were adjusted to reflect the earliest time period in which the students watched the videos, with each student appearing in exactly one cohort. The *Pre-exam* cohort of students performed better on the interactive portion of the final exam than the other cohorts in videos 6.2Q* and 8.1Q. For the multiple-choice section of the exam, the data shows that the *Pre-activity*, *Post-activity*, and *Pre-exam* students significantly had better grades (e.g. 91% in 6.2Q*, 97% in video 8.1Q from the *Pre-exam* cohort) compared to the *Never* cohort (86% in video 6.2Q*, 83% in video 8.1Q). Therefore, students who watched the videos, regardless of when students watched, outperformed those who never watched them for both question types in 6.2Q* and 8.1Q. Although the data is limited in size for this portion of the analysis, there are three interesting anomalies. First, the *Pre-exam* did better than the *Post-activity* cohort (see 6.2Q* multiple choice), perhaps because the information was fresh on their minds. In video 8.1Q, the *Pre-exam* students did not significantly do better than all other groups. We believe this was because the students who watched the videos before the lab activity gained a more appreciative and deeper understanding of the class materials and work enough in the group projects for the class. Moreover, the *Pre-exam* group did not do as well as the *Never* cohort in the 8.1Q interactive questions but did significantly better on the multiple-choice questions. We believe this could be attributed to the fact that students in the *Never* cohort did not watch the videos and understand the theory, but perhaps they learned the software well enough in the course's group project to still do well in the interactive section. In closing, we would like to note that earlier data in the pilot study indicated that quizzes in videos do not impact whether students watch the videos, however; watching the videos will typically have a positive impact on the performance and learning outcomes for the students on the final exam grades. These were only a few points of reference and some groups had small cohort sizes, so a larger study will be needed in the future to confirm these preliminary observations.

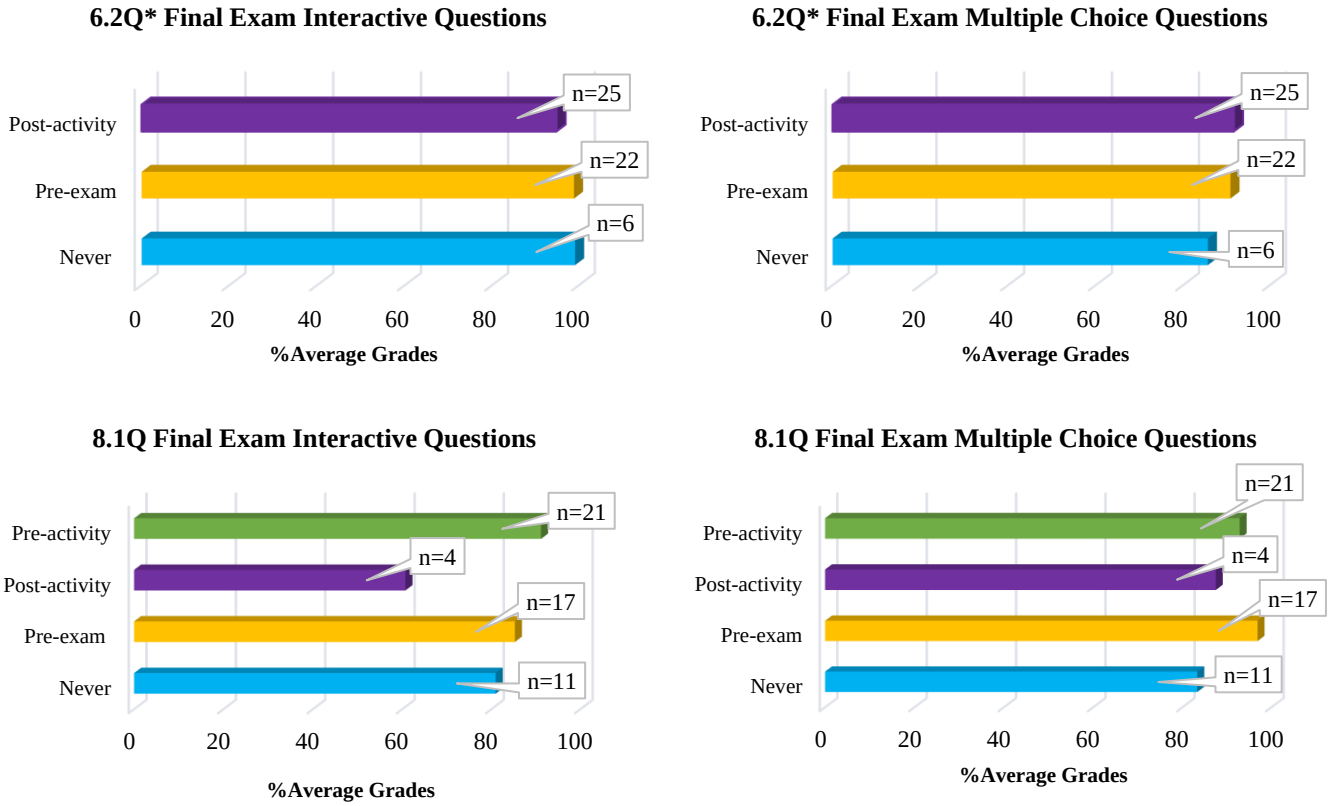


Figure 4: % Average final exam grades for four cohorts of (*Pre-activity*, *Post-activity*, *Pre-exam*, and *Never*)

4. Conclusion

The second half of an industrial and systems engineering simulation course with 53 students enrolled during the Spring 2019 semester was converted to a flipped classroom teaching strategy in this pilot study. There was a total of 9 medium-length (30-50 minute) videos across chapters 5-8; 4 videos had no activity, 4 videos had non-graded quizzes,

and 1 video had a graded quiz at the end of videos. The goal of this research pilot project was to investigate the video engagement and learning outcomes for Gen-Z engineering students in a flipped classroom environment for a software-intensive course. We presented a statistical analysis of patterns seen in the students' video engagement and learning outcomes for the selected course. The statistical results also reveal a few preliminary observations. First, the number of students who watched the videos decrease as the semester progresses. Meaning students had more motivation to watch the videos when they were first introduced but lost the motivation throughout the semester Moreover, on average, about 11 students per video (or 20.7%) waited to watch to the videos in preparation for the exam instead of staying on track with the course. Second, the quizzes in videos do not impact whether students watch the videos, however; the data suggests it can impact the performance on the final exam grades. The students that achieved the same grade in the *Pre-activity* and *Post-activity* cohorts, scored better than both cohorts of the *Pre-exam* and *Never*. Future work will investigate the effect of video length and video content (e.g. active-learning videos) to observe the change in video engagement and student performance.

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