TEACHING SIMULATION TO GENERATION Z ENGINEERING STUDENTS: LESSONS LEARNED FROM A FLIPPED CLASSROOM PILOT STUDY

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ABSTRACT

Simulation has been a long-time staple for industrial and systems engineering programs. Today's engineering students known as Generation Z (Gen-Z) exhibit specific generational traits including short attention spans and multi-tasking on multiple digital screens. These Gen-Z preferences have created new challenges and opportunities for the delivery of simulation methods and training in a classroom. In this paper, we present motivating factors and success in converting a software-intensive undergraduate-level simulation course to a flipped classroom setting. Furthermore, we present lessons learned from a multi-semester pilot study that investigated the impact of video length in lecture-length 40-50 minute vs. short-length 10-12 minute videos. Surprisingly, Gen-Z students preferred lecture-length videos. This paper shares our experience in transitioning from traditional to flipped classroom lectures for teaching simulation to Gen-Z engineering students. We share student feedback about the transition process, key tips for communicating expectations and deliverables, and how to minimize video burnout.

1 INTRODUCTION

The group of individuals born between 1996 and 2010 (Rothman, D. 2016) comprise the majority of our college students today and are known as Generation Z or Gen-Z. The earlier Millennial generation brought their own challenges, but Gen-Z is forcing changes in higher education more than ever before (Cilliers 2017). Due to the short attention spans of Gen-Z students, higher education instructors are transitioning to more active-based learning techniques specifically with case studies and direct applications in class to keep Gen-Z students engaged. Gen-Z works, thinks, and prioritizes differently than Millennials and therefore it can be expected that their preferences to learning are different as well.

At the University of Florida two undergraduate simulation instructors received specific feedback from a midterm evaluation in which students were having difficulty keeping pace during live model building exercises. In the moderate class size (e.g. $50 - 70$ students), it was impossible for the instructors to teach and help every student debug their models in a single lecture period. The students were falling behind in class and were requesting supplemental videos to engage with outside of class. As a solution, the instructors developed recorded live lectures so that students could review the demonstrations and explanations. However, the instructors learned quickly that although students now had access to videos, this was not the method they prefer, and there was a stronger interest in converting to a flipped classroom.

Flipping a simulation class requires complete learning at home while class time is reserved for activities (Koulopoulos and Keldsen 2016). Flipped classrooms give students the ability to self-pace and allow time for students to match the reasoning (why they are doing something) to the performance (what to do) in

an individualized way. This allows for students to learn the material for applications rather than replicate the instructor's actions and not understand *why* they did each step. Additionally, the ability to pause and rewind videos alleviates the stress students may feel trying to follow along in a new software environment.

The instructors found that implementing a flipped classroom was highly effective for the software-intensive portion of the undergraduate simulation class. The new flipped classroom design has been implemented across four semesters over a two-year period. During the transition, the question remained of how long the videos should be. The unexpected (and possibly controversial) results indicate that the Gen-Z engineering students strongly preferred to watch a single lecture-length video compared to a mini-series of short videos when building models through software demonstrations. In this paper, we share the instructor experiences, course outline, pilot study design, lessons learned, key tips, and video engagement statistics collected. Specific quotes from student feedback are also included to provide motivation for the transition to a flipped classroom and to share the student perspective (both positive and negative) after the transition.

2 LITERATURE REVIEW

The traditional method for teaching simulation in higher education relies on in-class software demonstrations. Students are then expected to replicate those methods on their own in a lab or homework assignment. However, personal experience, student feedback, and literature are showing increasing evidence that incorporating interactive methods in a class increases student engagement and perceived learning (Greenwood 2017; Eijkman 2012; Hamdan et al. 2013). Möller et al. (2013) presents an integrative concept for embedded modeling and simulation by incorporating enhanced technology which simplifies the qualification, production, and implementation of ubiquitous learning processes. There has been an increasing interest in converting traditional classes to flipped (Bergmann and Sams 2012; Alvarez 2012). In fact, these pedagogical approaches have been implemented on different cohorts such as K-12 (Banks and Sokolowski 2010; Slemmons et al. 2018) and higher education courses (Guo et al. 2014). The ease of access and implementation of video technology integration in the classroom has not only been a valuable inspiration for student learning, but when integrated with a flipped classroom format, can improve student learning outcomes and create a positive and creative learning environment.

It is not just the addition of integrated videos that make for a successful flipped classroom, but rather the whole approach of video development, integration, and activities that keep the students engaged (Tucker 2012). A flipped classroom moves the two fundamental concepts of Bloom's Taxonomy (remember and understand) to the home environment, while the more complicated concepts (apply, analyze, evaluate, and create) remain in the classroom (Forehand 2010; Bolatli and Korucu 2020). This is important since the top four categories of learning objectives are the most difficult to implement and increase student learning and retention. However, for "at home" videos to elicit student engagement, instructors need to follow best practices for creating and delivering videos to their cohort of students. To begin, we focused on determining the optimal video length for high engagement levels and learning outcomes. Slemmons et al. (2018) shows the impact of video length on student engagement of K-12, reporting that students have higher engagement with videos shorter than 11 minutes. Probably the most popular study on the topic by Guo et al. (2014) shows the impact of video length on Massive Open Online Courses (MOOCs) and reports that short videos less than 6 minutes elicit the highest student engagement. Some studies have implemented short videos (e.g. 5-10 minutes) in flipped classrooms, such as Santiago and Guo (2017) for learning MATLAB in an electrical engineering course. Thus, we originally set out to confirm that short videos were indeed the best approach for teaching simulation to Gen Z students in higher education. However, we were astonished to learn otherwise. Looking back, the Santiago and Guo (2017) study had similarities to our traditional higher education simulation course, (e.g. software-intensive engineering course), but there were some differences (e.g. nontraditional students and they were not aiming for lecture replacement). In a software-intensive simulation course, building large models cannot be explained or demonstrated in less than 12 minutes. In our experience, building intermediate and advanced simulation models would require 16-18 short videos (See Chapter 5 of this pilot study) to achieve that video length. Beatty et al. (2019) found that when too

many parts are introduced, student engagement drops off significantly. There is still minimal data-driven results on best practices for software-intensive higher education courses with moderate enrollment levels ($50-70$ students). Thus, we were motivated to document our experiences during the transition to flipped classroom learning for simulation education.

3 MOTIVATION FOR FLIPPED CLASSROOM

The main objective when teaching an undergraduate simulation course is for students to model a real-world system into a virtual one (Loper 2015). It is challenging for beginners to visualize how to model a physical object in a digital space. New modelers struggle with how to draw abstractions (defining entities, resources, etc.) from the real system and how to implement them in the software (programming). While the former can be learned through practice, the later is most effectively taught through sequential software demonstrations that introduce increasingly advanced software features. The latter can be tedious and difficult. A single missed step will cause the students to fall behind the pace of the instructor. With a large student to faculty ratio, it is impossible to provide every student with one-on-one learning and debugging support. Therefore, instructional strategies outside the classroom are necessary.

At the University of Florida, two instructors were teaching computer simulation in the traditional face-to-face style. However, mid-semester course evaluations revealed that students were struggling to keep pace in the course. Appendix A.1 lists select quotes from the evaluations, including "Pre-recorded lectures are MUST..." and "It would be more helpful if we watched videos...". The demand for pre-recorded lectures and a flipped classroom was overwhelming. The instructors began to investigate Gen-Z student characteristics and found that many Gen-Z students consider YouTube as the main source of learning (Genota, L. 2018). They multi-screen on 5 to 7 devices at once (Bergmann and Sams 2014) and would surely embrace the juggle between lectures slides, videos, and the simulation software. In response to the feedback, the instructors decided to implement a true flipped classroom for the second half of the undergraduate computer simulation course. The instructors wanted to determine the optimal video length and subsequently developed a multi-semester pilot study to compare single lecture-length videos to a mini-series of short videos. The next section describes the pilot study design and outcomes.

4 PILOT STUDY DESIGN AND OUTCOMES

This section describes the pilot study design, topics, videos, and activities. The course is a required undergraduate simulation course in an Industrial and Systems Engineering program. Students typically enroll at the beginning of their senior year. The course objective is to introduce students to basic techniques for discrete-event simulation modeling and simulating industrial systems in the presence of uncertainty. Students are expected to learn discrete-event modeling, implementation, input/output data analysis, and complete a course project. The course utilized Arena software (Rockwell Automation 2020) and is based on the text by (Kelton, Sadowski, and Swets 2009).

4.1 Chapter 1-4: Traditional Lectures and Hands-On Activities

The simulation course begins with a review of statistics, moves into definitions of a simulation model, and then moves into building models. Early conceptual models introduce simple service systems (e.g. sandwich shop or a drive-thru). **Key Tip 1: Keep the first third of the material taught in the traditional face-to-face style class to build foundational knowledge and delay video burnout.** In this way, the instructor can gauge the students' understanding of statistics and the underlying terminology of a simulation. This allows for building a foundation in simulation modeling. However, students still struggle to understand the basics of a simulation such as 'events' and collecting counter, tally, and time-variable statistics. So the instructors developed a mock simulation as an in-class activity to help students connect a real system to an event process and data collection and analysis.

4.1.1 Mock Simulation

The instructors of this course developed an in-class activity in which the students act out a simulation. The activity includes note cards with arrival and service times. Students act as entities in the system and line up based on their arrival time. Using a displayed stopwatch, students (entities) arrive to service at their given time. They are serviced by the instructors (resources) for their given time and released from service. They then move into a 30-sec delay area and exit the system. This is an 8-minute exercise, with a 2-minute practice exercise. During this exercise the rest of the class collects arrival and service completion times. They are provided with a table and then are asked to complete total service time and total time in queue. The instructions and materials for this exercise are openly available for instructor download (Alvarado and Basinger 2020). This exercise helps students visualize the main parts of a model before they begin building one.

4.2 Chapters 5-8: Flipped

A flipped classroom is appropriate for this material once students begin interacting with the software to build computer simulation models. The instructors have found that the optimal point in which to pivot to a flipped classroom is to wait until the models get complicated (e.g. modeling a call center). Students will use the videos at home to learn the intricacies of the software, but have developed the ability to think through a real-world scenario and try to visualize it for implementation in the simulation software.

The instructors originally broke up these software-intensive chapters into lecture-length (e.g. 30-50 minute) videos. A total of 9 lecture-length videos for 4 chapters of the textbook were recorded. The videos by topics are shown in Table 1. The videos are labeled by chapter and video number (e.g. Video 5.3 is for Chapter 5, Video 3), and designation 'Q' indicates the video had a quiz (e.g. 5.4Q). **Key Tip 2: When flipping a class, make class days optional when students are expected to watch lecture-length videos**. If instructors expect students to watch videos at home, then the students cannot be expected to attend the class for additional lectures, nor should the students be given more work to do at home. Class time is for the activities they would have completed outside of class in a traditional classroom.

The success of a flipped classroom is more than just providing videos on the right topics at the right time. There are other factors to consider. **Key Tip 3: Do not add more assignments to fill class time.** Students will spend a significant amount of time at home watching videos and building models; adding extra work will only deter them from making time to watch the videos (Felder and Brent 2015). An instructor must also consider the way the information is presented to the student. **Key Tip 4: When providing videos to students, you should include the length of the video as well as the topics covered in the video.** The instructors of this flipped classroom did this based on the feedback of students regarding the difficulty of navigating the course website for appropriate videos. Figure 1 is a depiction of the format used in the course. Students also need to know *when* they are supposed to have watched which videos. **Key Tip 5: Create a schedule for students so that they can stay on track. Be sure to link each video to a planned in-class activity so that they have a soft deadline for watching the videos.** Figure 1 also show an example communication schedule for one week.

4.2.1 Video Engagement Results

Data was collected throughout each semester to track when students watched the videos and how much they watched. The instructors wanted to track the video effectiveness and know if students were prepared for the in-class activities. The Mediasite platform used for the pilot studies recorded who, when, and how long students watched an individual video. Using this data, the students were divided into three cohorts: 1) Pre-activity cohort are those students who watched the videos by the scheduled due date before any corresponding in-class activity (e.g. Lab); 2) Post-activity cohort are those students who watched the videos by the due date of the homework assignments; 3) Pre-exam cohort are students who watched the videos in preparation for the final exam (before the final exam). The software tracks the video coverage, which

Table 1: Summary of video lengths and topics.

Chapter	Video	Label	Length (Min)	Topics	Class Attendance	Details and Deliverables
5 Modeling Detailed Operations	1	5.1	0:38:24	Call arrivals, Cut-off logic, Tableons, Storage	Optional	None
	2	5.2	0:53:14	Tech, Sales, and Order status, Blocks and elements panels, Shared queues and Priorities	Optional	Submit model
	3	5.3	0:48:24	Arrival schedules, Resource schedules, Sets, Resource sets, Record into sets, Preferred order	Optional	None
	4	5.4Q	0:36:42	Tech, N-way by condition, Simultaneously seizing resources, Specific member, Variable array, New systems variables	Optional	Submit model; Lab 4
6 Statistical Analysis of Output from Terminating Simulations	1	6.1Q	0:39:04	Overview and terminating vs. steady state, Statistical issues with Simulation, Confidence intervals explained, Numerical CI example, number of replications, Example number of replications	No class	Graded quiz
	2	6.2Q	0:38:33	Overview Paired T-test , Output analyzer, Process analyzer setup and graphs	Optional	None
7 Modeling and Steady State Statistical Analysis	1	7.1	0:43:35	Verification vs. validation, model 7-01 - problem overview, model 7-01 - modeling details, Model 7-01 - sequences, Model 7-01 - other modeling parameters, New vs old machine	Optional	None
	2	7.2Q	0:38:30	Warm-up period, Truncated replications, Interval batching logic, Interval batching, output analyzer	Optional	None
8 Entity Transfer	1	8.1Q	0:32:36	Entity transfer using resources, Entity transfers using a transporter and animation, Entity transfer using a conveyor	Optional	Lab 5

is the percent of the total video length watched for each student. The video coverage had to be greater than/or equal to 60% to be classified into one of the three cohorts of students who watched the videos. Lastly, we considered the 4) Never cohort for students who never logged in to view a specific video or who had video coverage less than 60%.

The pre-activity data did not exist for Chapters 5 and 6 as the selected activity only related to Chapters 7 and 8. Figure 2 shows the percentage number of students assigned to each cohort according to a cumulative summation. The first positive trend shown in the data is that the Never cohort represents a fairly small portion of the students. In fact, on average 87.8% watched all the videos. However, there is a trending decrease in the number of students who watch the videos as the semester progresses. Intuitively, this means students have started watching the videos with higher motivation, but this diminishes as the semester

Chapter 6 (Output Analysis of Terminating Simulations)	Mon, March 25
Chapter 6-8 Schedule.docx. ⬇ Remember all presentation files and models are here: Chapter 6 files. Video 1 (confidence intervals, number of replications) - GRADED QUIZ ⬈ Video 2 (paired t-test, output analyzer, process analyzer) ⬈	• In-class: Instructor support for Chapter 6 Videos 1 and 2. (attendance optional) • Deliverables: none • After-class: Watch Chapter 7 Video 1 (43 minutes) **Wed, March 27** • In-class: Instructor support for Chapter 7 Videos 1 (attendance optional) • Deliverables: none • After-class: Watch Chapter 7 Video 2 (38 minutes)
Chapter 7 (Steady-State Statistical Analysis) Chapter 6-8 Schedule.docx. ⬇ Remember all presentation files and models are here: Chapter 7 files. Video 1 (verification, validation, sequences) ⬈ Video 2 (warm-up period, truncated replications, interval batching) ⬈	**Fri. March 29** • In-class: Instructor support for Chapter 7 Video 2 (attendance optional) • Deliverables: none • After-class: Watch Chapter 8 Video 1 (32 minutes)

Figure 1: Screenshots the course design for Chapters 6 and 7: video links and communication schedule.

progresses. This trend is referred to as "video burn-out" and is even further motivation to keep the first third of the class, in a traditional setting.
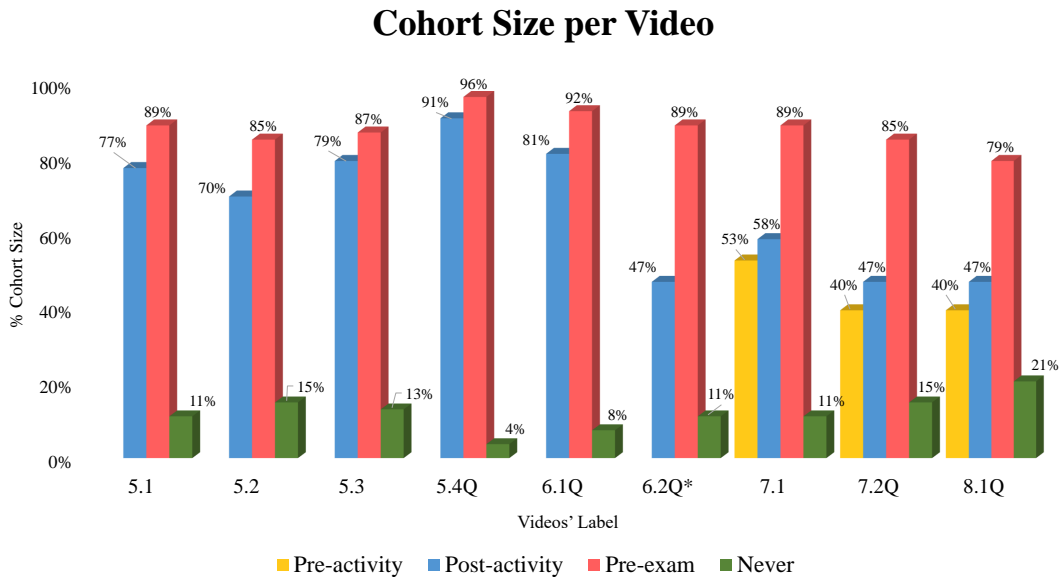

Figure 2: Percentage of students in each cohort for lecture-length videos.

Secondly, notice when the students are watching the videos. The first five videos had a small but noticeable increase (e.g. 5-15%) in the percentage number of students who watched videos in preparation for the final exam (between Post-activity and Pre-exam cohorts); however, the increase was much more considerable near the end of the semester (e.g. 31%-42%). To our surprise, in Chapters 7 and 8 videos, only 40%-53% of the students watched the assigned videos before the lab activity; and only a few students (e.g. 5%-7%) watched it to complete the assigned homework. Therefore, assigning videos in preparation for the lab activity was not enough motivation to get students to watch the videos. Around half of the

students later watched the final four videos while preparing themselves for the final exam or to work on the semester project. More results are available in (Lahijanian et al. 2020) on video coverage and quizzes.

Figure 3 shows data from Video 7.1 in two separate semesters. One semester students were given lecture length videos (green), and in a subsequent semester students were given multiple short videos (purple). The sum of the short videos was within two (2) minutes of the original video. The data shows students tended to watch more of the lecture-length videos than the short-length videos. To our astonishment, nearly 40% never watched the short videos compared to only 11% never watching the lecture-length videos. The recommended practices for keeping videos as short as 10-12 minutes (Lagerstrom et al. 2015; Slemmons et al. 2018), or even 6 minutes (Guo et al. 2014), do not appear to apply when used as a mini-series in place of a single, larger video. The results are further discussed in (Alvarado et al. 2020) regarding student responses to short-length videos and is still an ongoing research topic for the authors.
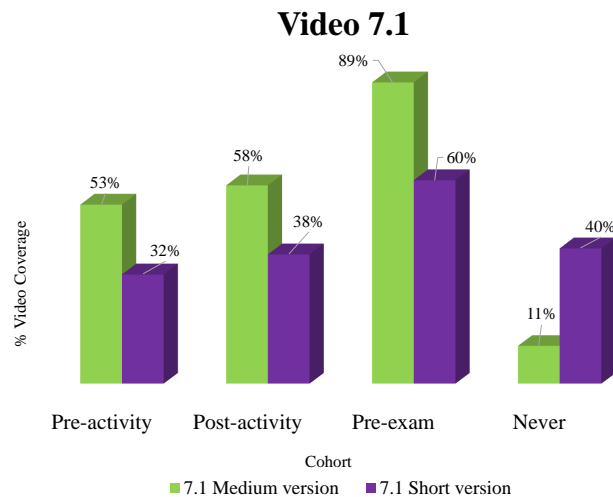
Video 7.1

Figure 3: Percentage of students who watched videos by cohort for video 7.1 in two subsequent semesters.

How long should your videos be? The answer is still unclear. However, the pilot data from this study shows that students are much more likely to engage in a single lecture-length video, rather than multiple short videos. We believe this partly attributed to the fact that when students are presented with multiple parts of the same video, engagement falls significantly with the addition of each part (Beatty et al. 2019).

5 LESSONS LEARNED

In this section we detail observations from student feedback after transitioning to the flipped classroom setting and summarize key tips and improvement strategies.

5.1 Student Feedback After Implementing a Flipped Classroom

After implementing the flipped classroom, feedback was collected through the final course evaluations at the end of the semester. Select quotes are available in three subsections of the Appendix: Appendix A.2 contains selections from the positive feedback supporting the transition to the flipped classroom; Appendix A.3 gives negative feedback in response to the transition, and Appendix A.4 provides specific suggestions for improvement. In summary, there are several themes among the responses that are worth noting:

1. **Student opinions are polarizing.** There were many evaluation comments supporting the conversion where students expressed gratitude and appreciation for the videos, with some even proclaiming that they learned more after the transition. However, there were several students who also expressed negative comments regarding the flipped class portion of the course. These students found the online

format to be more difficult to engage with and preferred the traditional in-class lecture format, with the videos made available as a supplement.

2. **Student suggestions for improvement.** There were several helpful suggestions for improvement and gratitude for specific policies that were implemented that are worth sharing:

   (a) **Improve Video Quality.** Several lectures (especially those first recorded) did not have optimal settings (e.g., the software application was recorded but the cursor was not, or the resolution was of low-quality). These were learning errors on the part of the instructor that improved for later videos and later semesters. Additionally, using the built-in laptop microphone caused the audio to occasionally fade in and out, unpredictably compromising the audio quality.

   (b) **Remove Errors.** Occasionally the instructors made an error in the model build. The errors were not removed for two reasons 1) The Universitys Mediasite license supports clipping videos, but does not support partially re-recording segments or combining videos, thus making it difficult to edit without re-recording the entire lecture. 2) They were thought to be learning opportunities for debugging on compilation errors and runtime errors. A few students appreciated the errors remaining in the final cut, but others did not.

   (c) **Shorter Video Lengths.** A few students expressed trouble staying focused on 45-50 minute lectures and requested videos of shorter lengths.

   (d) **Optional Course Attendance.** Some students felt the videos were extra and did not want to attend class after watching the videos. The instructors were aware of this potential concern so some classes were canceled in place of the videos, but there were some pre-scheduled labs and group project sessions that were still required.

   (e) **Post All Videos at Beginning of Semester.** In the first semester the videos were posted just before they were assigned because they were recorded as the semester progressed, but students requested earlier access, such as setting up the course page from the beginning of the semester.

   (f) **Active Videos.** In the initial implementation of the flipped classroom, the course instructors used passive videos where students simply watched and took a quiz at the end of the video. However, there was interest in having more active videos that support student interaction (e.g. decision-making and branching) and commenting (e.g. flagging or posting questions).

5.2 Key Tips and Improvement Strategies

The instructors from the course have spent two years developing a flipped class for an undergraduate software-intensive simulation course. Below is a summary of the key tips to consider when **transitioning from traditional to flipped** in a technical or software-intensive course for Gen-Z engineering students.

Key Tips:

1. Keep the first third of the material taught via traditional style class to build fundamental knowledge and delay video burn out.
2. Make class time optional during sessions when students are expected to watch lecture videos at home.
3. Do not add more activities to the course to fill class time. Remember they are spending a lot more time learning outside of https://www.overleaf.com/project/5ea27720d8c4ac000102a447class now.
4. Provide a detailed table of videos including lengths and topics.
5. Provide a comprehensive schedule of when students should watch the videos to stay on track with in-class activities.

In response to the student feedback and suggestions for improvements, we are continuing to enhance the pedagogy in our flipped classroom. Aside from the Key Tips, the instructors also recommend the following improvement strategies:

Improvement Strategies:

1. Update 2-3 videos each semester.
2. Enhance the videos through new platforms (e.g. Playposit, Cinema8) that support active learning.
3. Keep a running list of errors or confusing problems to revise in future semesters.
4. Utilize a recording studio or high-quality microphone to maximize video quality.

Based on feedback from the first and second semesters of the pilot study and literature suggesting that videos should be short ($\leq$ 10 to 12 minutes) (Lagerstrom et al. 2015; Slemmons et al. 2018), the instructors re-recorded and edited videos to create a short format. However, the results indicated students are not engaged when there is an overwhelming number of videos, even if they are short. This research is still ongoing, in a subsequent semester where students were presented with the choice of one lecture length video or 2 to 4 short videos. Preliminary data results show an overwhelming majority that students prefer one longer video to several short ones.

Our research team is now investigating methods for transitioning the videos from *passive* to *active* learning. In passive videos, students watch but do not interact with the videos and quizzes do not affect the videos in any way. In active videos, students make decisions that affect the videos (e.g. branching) or can flag sections of the video that are not clear, and more.

6 CONCLUSIONS

Rapid technology advancement changes the way that higher education courses are taught, especially as we experience generational differences among students. It is important to aim for continuous improvement and never rest on the idea that what was created for one cohort of students will work for another. For Gen-Z students, the instructors recommend the flipped classroom approach for highly technical topics, such as learning a specific software for simulation modeling. This gives Gen-Z the control to learn at their own pace. Creating flipped classroom videos requires a strategic plan for lecture topics, video length, timing, and placement. The platform used for recording and distributing videos should be intuitive for students to follow both on how and when they should be engaged. Gen-Z students are excellent at multi-screening, and instead of trying to break the habit, we can use it to our advantage. Watching a lecture video while working on software development is completely within their norm. In fact Gen-Z demands the ability to learn on their own. These guidelines for a flipped classroom may not apply to all types of courses, but rather most applicable for technical and software-intensive courses such as learning programming languages or simulation modeling.

A STUDENT COMMENTS

A.1 Select Midterm Evaluation Comments that Motivated the Conversion to Flipped Classroom.

Question: How can the material covered in the class be improved?

- Being able to have tutorial videos on different lessons for the software used to rewatch later.
- It feels we're moving way too fast in class. The instructor clicks around super fast and moves on quickly, while we're struggling to just replicate it and not understanding the concept.

- The material covered in class contains a lot of simulation software. Sometimes we can get lost in all the clicks being done and only copying the Professor's model without understanding why we're doing it. Having software tutorial videos to watch at home would be better because we can come to class with questions and have a video to reference in case we forget a small detail.
- We need to go slower. Sometimes when the teachers are going so incredibly fast that we cannot keep up. It needs to be taught at a pace where we can keep up with the model.
- Pre-recorded lectures are a MUST . . . . Following the instructors is very difficult . . . If I miss a step it's game over, I cannot catch up and my simulation will not work. Very confusing.
- It would be more helpful if we watched videos of the instructor going through simulation examples before class and then worked on assignments in class with the instructor's help.
- I think that the way we set up the simulations should be different. Maybe we work on them at home so that when we come to class we can talk about questions that are particular to that assignment.
- Additionally, it would be great if tutorials on the software can be posted, or at least some external resources. It's hard to learn from class alone because it feels rushed and I'm just inputting numbers.
- Videos! And then in class we discuss them or review them.
- Provide more resources for students who prefer to learn the software on their own time.
- The simulation models in the software are great learning tools but are a bit hard to follow at times.

A.2 Select *Positive* Evaluation Comments on the Flipped Classroom.

- Online videos were great. A concise and informative experience.
- The videos helped A LOT!! Accessing the recordings to review them multiple times was great.
- The slides and videos were great! Very helpful.
- You should definitely stick to the video lectures, I learned 10x more with them for the second exam than I ever did before. Majority of students couldn't follow the labs in class.
- Video lectures should be continued because it is easy to forget the steps in the simulation software by just doing it once in class, whereas you can go back and re-watch lectures if there are videos.
- I really appreciate the course videos.
- I liked the quizzes in the videos because it helped me pay attention.
- I liked working on the videos at our own pace.
- I also liked the flipped classroom so that class time could be used more as office hours.
- This is a software class, should be a flipped classroom concept.

A.3 Select *Negative* Evaluation Comments on the Flipped Classroom.

- I think that although the videos were helpful, they were still very long and hard to focus on.
- I liked when we built the models together as a class, better than the videos.
- The biggest issue with this course is that no one felt like they were being lectured. Considering how much we pay per hour of class I felt that we could have had more lectures and instruction on the simulation software rather than being expected to watch the course lectures on our own. I believe that videos should be supplemental, but should not replace us being lectured.
- It is very difficult to retain everything that is spoken to in the video (because there are mistakes sometimes). Therefore, it would be beneficial to have slides that clearly cover information. Also, I was not a fan of the videos. I think they should be supplemental for students to go back and review.
- I think the videos were a lot. Attendance was required for the course and then on top of that we were given extra videos that were mandatory for our success in the course.
- It was frustrating how the videos would sometimes mess up the program and you would not know until the end. Even some text boxes to point out there was an error would be helpful.
- During the second half of the semester, it was much harder to retain information because it switched to videos instead of class. The videos should still be available, but only as supplemental information.

- I also did not like how the video lectures were not explained in class once they were posted.

A.4 Select *Improvement Ideas* from Evaluations of the Flipped Classroom.

- The videos had a couple mistakes but I thought even those mistakes were helpful because I could have easily made the same mistake and not known!
- The videos probably should be cleaned up and edited a bit to take out some of the mistakes.
- I wish there were more in class lectures with more preparation beforehand. Videos should be shorter, because they were sometimes very difficult to watch and pay attention for the entire time.
- Add videos to the course website from the beginning of the semester.
- I think that although the videos were helpful, they were still very long and hard to stay focused the entire time. I did appreciate canceling class some days to catch up on the videos.
- Some of the videos do not have the best quality so it is hard to see where the cursor is pointing.
- There is a bit of polishing to do to ensure the videos match the slides and textbook. If I were to edit or change anything it would definitely be the slides to better match the videos.
- Not requiring us to turn in the practice on every video was a nice gesture to maintain a manageable workload. (Thanks for that!)

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