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Transforming Introductory Engineering Courses to Match GenZ Learning Styles

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Abstract

Recent pedagogical studies indicate that short, focused content presentations followed by interaction and assessment are more effective in teaching GenZ (ages 17-22) students. By redesigning two high enrollment lower division courses at the University of Idaho, Introduction to Computer Science and Engineering Statics, and targeting GenZ learning styles, we hoped to improve both our retake and retention rates.

Since GenZ students are familiar with video technology as part their education, we had instructors record short video segments which corresponded to in-class lectures. In conjunction with the Engineering Outreach program, an office was repurposed into a small faculty recording studio where the videos could be recorded at times which could easily fit within the schedule of a faculty member. We offered short training sessions for the instructors to learn how to use the equipment. The goal was to develop a library of review modules so that if a student did not understand a particular topic which was covered in class, the student could review the video as many times as necessary to master the concept. In addition to the review modules, example problems and their solutions were also recorded to allow students to develop their problem-solving skills.

During the spring 2020 semester in Engineering Statics, 51.4% of the students viewed at least one video with an average of 2.6 views per student overall. The switch to the online classes due to the pandemic shutdown had a dramatic effect, where 87% of the overall video views occurred prior to the switch and only 13% occurred after the switch. For the Introduction to Computer Science course, all students viewed at least one video with an average of 13.3 views per student. The number of videos viewed per student after the switch to online showed a slight increase relative to the fall 2019. In both classes, students reported only watching videos on topics that they found most difficult. Videos on more fundamental or more difficult topics had higher viewership. Results suggest that students were using the videos as supplemental materials and that the videos were successful in helping students master the course material.

Introduction

Students entering the University of Idaho, and universities in general, use digital media to advance their academic careers and have been exposed to this technology for all of their lives. This Generation Z cohort, students roughly between the ages of 17-22 have particular learning styles and it is important as engineering educators to modify our teaching methods to best meet their needs. Kalkhurst [1] writes that GenZ students are disrupting many ingrained practices in education and that colleges and universities are forced to adapt at a rapid pace or become irrelevant. GenZ students are accomplished self-learners, can process information at a fast pace and it is important to be brief and visual to capture and hold their attention [2].

Seemiller and Grace [3] highlight an important characteristic of GenZ learners: a short attention span and a need for immediate feedback. Since GenZers rely heavily on technology, there is little patience for time delays. Therefore, technology-aided instruction should be seamless. Cook [4] notes that GenZ students crave learning enhanced by technology and that they respond to visually enhanced teaching methods. She also emphasized that communication is typically brief (think texting). Having said that, they still value interactions with instructors as part of the higher education experience [5]. The same study showed that 82% of students use *YouTube* and that 59% prefer *YouTube* or apps to printed books for learning. A recent LinkedIn study [6] showed that 43% of GenZ learners are self-directed or independent learners, yet only 20% of teachers plan on offering self-directed learning experiences. Instructors should focus on engagement tactics to encourage GenZ students to be active participants in learning. Mohr and Mohr [7] recommend adjusting assignments and communication techniques for GenZ learning styles. Since GenZers are digital natives, they feel comfortable going online and using technology to help solve problems.

Researchers are understanding the challenges associated with teaching GenZ students. Cilliers [8] emphasized the need for instructors to incorporate technology, software and hardware into the classroom. She also mentions the need to move from traditional teaching approaches to more learner-based learning. Moore, et al.[9], suggest five ways to help engage GenZ students. One is to integrate online, out-of-class learning opportunities with in-person classroom instruction. This works well with GenZ students' desires for more independent, self-paced study. They caution that production quality expectations are high, and that even small recording studios can improve the quality of recorded lectures. Another important engagement tool is to assess often and provide timely feedback. Giving process-oriented feedback to problem solutions and helping students develop self-management and self-appraisal techniques were shown to be most effective.

Sabag and Kosolapov [10] have discussed the importance of providing instant feedback to enhance learning. They stated that providing rapid feedback helps keep students engaged and participatory in the material presentation. Waldorf and Schlemer [11] describe an "Inside-Out" model where 10-15 minute video snippets of pertinent course material is pre-recorded, then class time is reserved for practice problems or hands-on learning. They discuss the importance of students' staying on task and of having face-to-face working sessions for collaborative problem solving.

In this project, which is a follow-on of an earlier study [12], we incorporated online digital media and other focused tutorials in two core College of Engineering courses, involving 238 students. We proposed to transform the engineering curriculum through instructional experiences incorporating 5-7 minute focused video modules, guided student learning experiences based on active learning principles, rapid feedback and assessment strategies to improve the delivery of our Introduction to Computer Science and Engineering Statics courses. As part of this effort, we created a user-friendly recording studio, developed instructional experiences tailored to GenZ learning styles, and offered assessment activities to monitor content mastery. These are valuable pieces of instructional infrastructure that will be leveraged in future course development and integral parts of subsequent proposal development.

Recording Technology

The Engineering Outreach (EO) program at the University of Idaho has extensive experience recording and distributing course material. A former office space was transformed into a recording studio and was designed so that faculty could easily use the controls to adapt their current, in-class teaching style. It features a self-service recording method intended to keep faculty training to a minimum. Following a 10-minute orientation, faculty members can schedule a time in the studio and record as much footage as desired. Faculty interface with the recording technology via a record/stop button and a set of camera-switching buttons (optional).

Two cameras were installed in the faculty studio. The first is a document camera allowing for faculty to include hand-written notes and pictures in their videos. The second camera (the Instructor Cam) was installed to be kept on the instructor during all recordings. The instructor cam feed is shown via picture-in-picture over the material provided in each video. This picture-in-picture method was suggested as a way of adding a personal, human element to the material. Feedback from early courses taught in this fashion confirmed that this human element included in the mini-review videos was well received by students. Audio/video mixers combine the signals and output the video file, which is saved to a high-speed SD disk for post-processing.

Multiple methods of material input were provided to adapt the studio to differing teacher preferences. The document camera allowed faculty to deliver live notes or show a page from a textbook, similar to a live, in-class lecture. A Microsoft Surface computer was offered to allow for digital material, such as a PowerPoint presentation, PDF, or website. The Surface also provided a digital pen which our team promotes as a combination of digital and hand-written notes. An adjustable height desk is included to accommodate the heights of various faculty members and a 50” TV monitor presents the live recording output. The original faculty studio can be seen live in action in Figure 1 (left).

Over a dozen faculty members used the studio in the summer and fall of 2019. This led to ample feedback for improvements. Audio quality of the recordings was identified as a concern—especially for faculty with non-native accents—with early recordings containing muffled vocals and substantial echo from the studio walls and high ceiling. The original lapel microphone was upgraded to reduce echoing and improve overall vocal quality. Six acoustic panels were installed on the painted walls of the studio (see Figure 1, right) and 8 acoustic panels were hung from the ceiling (not visible) to mitigate echo. The newly installed backdrop (not visible, discussed below) also helped to dampen room echo. These upgrades significantly improved the vocal input on the video modules recorded for the GenZ pilot courses in the spring 2020 semester.

Upgrading the faculty’s interaction with the studio and their material delivery was another central objective. Many presenters were frustrated with the original document cam’s picture quality, difficult configuration, and lack of fixed mount. These criticisms were resolved with the purchase of an upgraded Wolfvision document camera, identical to those found in classrooms around the University and permanently mounted to the studio desk. A black mat is now also mounted to the desk to produce more appropriate contrast in document camera recordings. A whiteboard on a wheeled frame was installed after several presenters, accustomed to using whiteboards during their normal material delivery, pointed out the lack of a whiteboard available for recording. Our team amended the studio with a whiteboard on a wheeled frame, allowing for quick repositioning by faculty. A second, larger digital tablet was also installed. A studio light-set and 3 different backdrops were added to improve faculty appearances on camera.

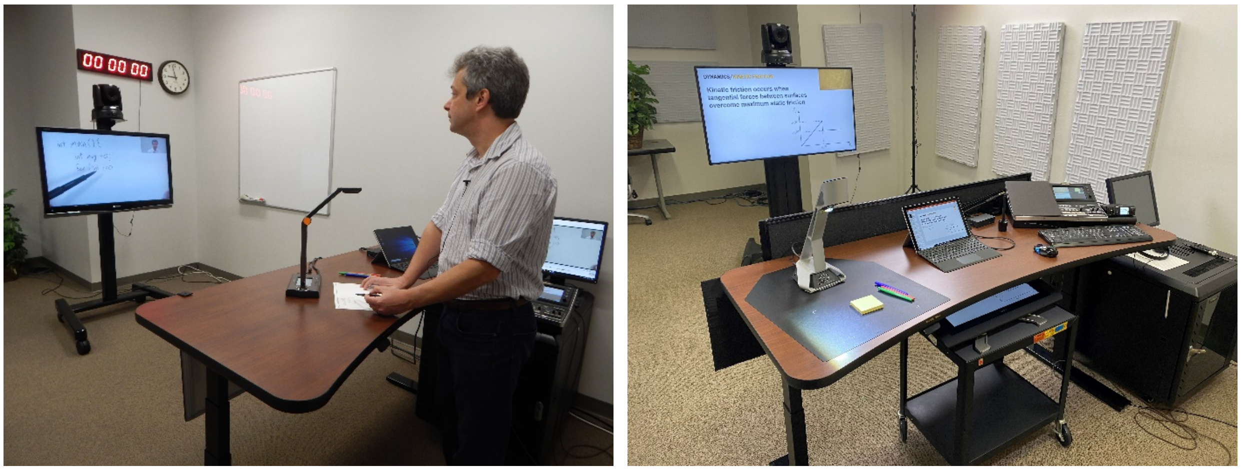

Figure 1: Original faculty studio, 2018 (left), and upgraded studio, 2020 (right)

Video Realization

Video modules were produced to offer instruction supplemental to the live classroom lecture. Forty-nine videos (20 topic review videos and 29 example problem videos) and 32 videos (30 topic review videos and 2 example problem videos) were recorded for Engineering Statics and Introduction to Computer Science, respectively. Each set of videos were created and recorded by the instructor of the respective course. This provided students with familiarity in teaching style between online and classroom lessons and provided the instructors an opportunity to properly complement the video material between sessions.

The original intent of the video modules as proposed was to provide 7-minute (or less) just-in-time reviews of topics as needed during homework applications. This 7-minute time constraint was decided upon originally to align with the desires of GenZ students for short bursts of viewing, but also fit well into the 12-minute restriction which is required under software licensing terms. It was discovered early in our pilot that a strict adherence to the 7-minute limitation was too restrictive for many of the planned videos and would require the instructor to either reduce the included material or to artificially separate the footage into two videos. Neither of these points were considered sufficient to maintain the original, relatively arbitrary 7-minute framework and we modified the concept to allow for single-topic review videos which were simply as short as possible to cover the material appropriately. Despite this alteration the average video length of all GenZ pilot course videos was only 8.2 minutes, with 76% of all videos being under 10 minutes in length (see Fig. 2).

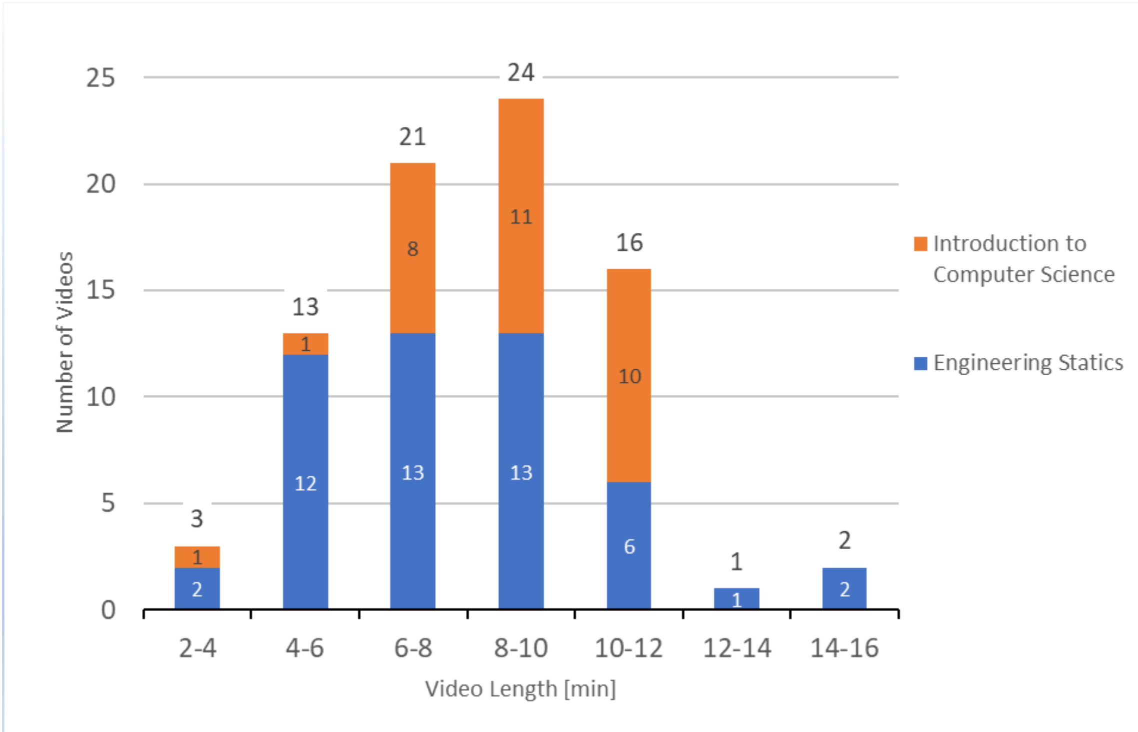

Figure 2. Video length counts

Faculty scheduled 1-hour blocks as needed for recording. The first recording session for all faculty featured a 10-15 minute orientation by a team leader to demonstrate the studio and address any questions. Faculty could then record material in any of the methods listed above, using a single record/stop button to create multiple recordings in one session.

All post-processing of videos was performed incorporating multiple review checks with the faculty member along the way to address concerns and incorporate feedback. Introduction and copyright sequences were appended onto videos and file sizes were compressed for web-based streaming. The completed video was stored on a server and delivered with a URL available only to students and faculty. By design, this URL allowed instant access to videos for other students and faculty looking for review or supplemental instruction in other courses. These URLs could then be distributed to students in a variety of ways, nominally through Blackboard course items.

Video Usage

For Engineering Statics, 49 videos were produced overall and delivered to a section of 37 students for the spring 2020 semester. Nineteen of these students (51.4%) viewed at least one video with an average of 2.6 views per student overall. The maximum number of views for a single student was 18; a student who reviewed example problems multiple times suggesting seeking procedural understanding of the solution. The total number of views across the entire semester was 97. The COVID-19 switch to online classes had a dramatic effect in the course, where 87% of the overall video views occurred prior to the switch and only 13% occurred after.

The course instructor offered several reasons regarding the relatively low usage of these videos. The videos were intended as supplemental materials, with their goal being to be an additional resource beyond traditional lecture courses. Several students mentioned that they never watched videos because the lectures and accompanying materials were adequate for successfully completing course requirements. Some students suggested that the recorded materials already existed elsewhere and that they reviewed those materials instead. The instructor also noted that many students did not fully participate in the course during the second half of the spring 2020 semester when the university moved to fully online instruction.

In the Introduction to Computer Science course, 32 video titles were produced and delivered to multiple sections across the fall 2019 and spring 2020 semesters (201 students overall). All students viewed at least one video with an average of 13.3 views per student. The maximum number of views by one student was 70; a student who watched 25 different videos evenly about 3 times each. The total number of views across the two semesters was 2694 (fall: 1835, spring 859). The number of videos viewed per student after week 8 in spring 2020 (switch to online) showed a slight increase (3.7) relative to the fall 2019 views per student (3.5) after week 8. This suggests that the utility of the GenZ video titles can be suitable in a completely online course.

The instructor(s) provided multiple pieces of feedback to support these data. Each topic was designed to have theory video(s) coupled with at least one practice video as a complete set for students. Students were encouraged to watch the appropriate videos before class to promote in-class discussion (a very slight shift towards a more flipped classroom). Two of the Introduction to Computer Science topics were not covered in-class—only in the videos—and these videos had correspondingly high view counts. Students generally reported only watching videos on topics that they were struggling with. Videos on more fundamental topics and more difficult topics had higher viewership. In addition, there was generally a spike in viewership before exams. Results suggest that the students were using the videos as supplemental materials and that, in this role, the videos were successful in helping the students master the course material.

Assessment Problems

Vision/Purpose

The second critical component of the GenZ course project was to develop a set of Blackboard assessment problems intended to serve in the course for which they were created for as well as offered as just-in-time review opportunities for faculty to assign in subsequent courses. These problems could either fill the gap between material review videos and graded evaluations or be used for graded evaluations as well; the former concept was favored by our team early on as it reduced the need to mitigate online answer resources.

A multiple-step randomization scheme of these assessment problems was envisioned by our team. For each assessment attempted by a student, Blackboard would draw random problems from a pool. These problems, nominally numeric STEM problems, would also have random parameters in their problem statements (e.g., different values of velocity or initial temperature, etc.) in further efforts to increase academic integrity—especially considering an online environment. Early ideas pursued by project personnel included an adaptive-release of these assessments during the sequence of a main topic or, potentially, an entire course. Our team pictured a process where students would need to score above a passing score for each assessment (potentially with other video content viewing criteria) before the next assessment would be made available. These concepts had been tested in an earlier course and showed enough promise to be carried into the GenZ project.

Development

Blackboard's problem creation software offers limited support for randomization of problems considering the scheme designed. Multiple-choice problems cannot be automatically randomized. Numeric-answer problems, in which a student types the answer into a text box on Blackboard, can be randomized but do not allow for the precision ("…to two decimal places…") required by the instructor of Engineering Statics.

Accordingly, we decided to use Microsoft Excel to manually create random problems. Excel would allow for variable parameter inputs to produce a single problem statement with randomized variants, each with its own answer. Once a problem was functional, as many rows (each an individual problem variant) could be created by a user as desired. Blackboard has a single-upload limitation of 200 variants, which was deemed sufficiently large and used for these problems.

Multiple problems were chosen from Engineering Statics texts and from the instructors' personal bank of self-created problems to be used for assessment problems. Each required a lengthy sequence of steps:

1. Images were scanned and altered allowing for randomization of parameters in the problem statement (e.g., a length of '4 ft' would become length 'L'). Typically, 2-3 parameters per image were randomized.
2. Problems were solved in symbolic fashion using the new parameters. This would produce the output function needed for Excel to produce the correct answer. Often this required a challenging solution process that took a significant amount of time.
3. Multiple incorrect answers were created to accompany the correct answer. These incorrect answers were usually random although some were based upon common mistakes made by past students.
4. The randomized parameters were then combined with the static text of the problem using Microsoft Word. Word allowed us to comply with Blackboard's required formatting for question uploading and provided copy/paste operations to easily produce the 200 problem texts.
5. Finally, the formatted questions were uploaded into a single pool at Blackboard. This is a simple operation after successfully completing steps 1-4, requiring less than one minute.

   Two example problem variants are shown in Figure 3, demonstrating varied input parameters, randomized answer sets, and required image manipulation (forces vary between 300 lb and 100 lb and the length L was made symbolic).

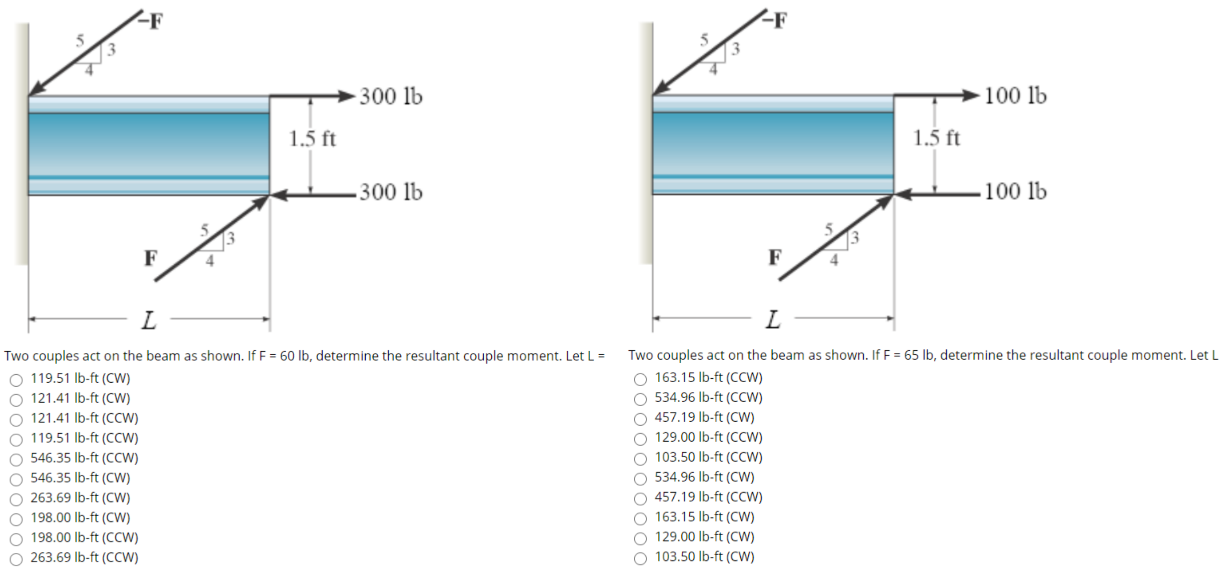

Figure 2. Two random problem variants

Delivery to Students

Once successfully stored in a Blackboard pool these problems could be distributed to students in any fashion desired by the course instructor, such as allowing multiple attempts of an assessment or imposing a time limit. The instructor of the Engineering Statics course opted to replace 2 paper-based assignment problems with 2 of our randomized Blackboard problems on several assignments coupled with a single paper-based problem for submission. These problems were given each in a single Blackboard assessment to allow for students to take each individually. At first, students often started Blackboard assessments and left them open in browsers for multiple days or weeks, adding complexity to a faculty analysis of student performance. Thus, generous 2-hour time limits were later given to ensure that students had ample time to solve a problem (expected to take ~15 minutes each) and that the Blackboard assessment would close automatically if a student did not complete it. The instructor was concerned about online academic integrity and thus made these problems worth fewer points than the paper-based problem.

The expectation of the problems delivered in Engineering Statics was that they were mostly practice problems, giving students:

- time to work through a solution procedure at their own pace;
- immediate response of their answers;
- feedback based on incorrect answers;
- opportunity for repetition of the same problem with different parameters, such that the student is not producing the same answer each time but repeating the solution procedure.

Results

Students showed an overall performance increase on the problems successfully delivered via Blackboard, with a mean score of 88.1%. Blackboard's grading scheme only stored the *final attempt* of the student's assessment, which eliminated the results of many attempts of students –

an unfortunate learning experience of the project. Only 2 of the problems were available for statistical analysis of their attempts.

The instructors of the pilot courses were generally positive regarding the motive and developed materials for the project. Both agreed that the videos should be considered supplementary and not fully replace in-class instruction. The Engineering Statics instructor felt compelled to make online assessment problems worth a portion of students' grades to enforce participation but wanted to mitigate the use of online answer resources as much as possible (i.e., worth enough credit to do, but not enough credit to cheat on). Notably, 57% students re-attempted at least one of the problems, some after a correct answer. This provided some optimism concerning the student utility of these problems. The instructor provided very positive feedback including "help faculty members develop their own homework problems" and "take aggressive steps to limit online answer resource use is an extremely valuable use" as a valuable use of initiative funding.

Difficulties with development, however, produced frustrating results of the Blackboard assessment problems. The problem development process was more difficult than anticipated during our initial plans and this provided significant frustrations and time consumption during the project. Blackboard's random problem generation tool would allow for a straight-forward creation of multiple problems during the rapid pace of a semester. However, this feature is only available for a certain type of problem which was not consistent with the format used by some faculty assignments. Therefore, we made the switch to offline problem generation with Excel which increased the time required to create each problem from minutes to hours. The Engineering Statics assignments were offered 3 times per week and the process began to fall behind very early during the semester considering these additional time requirements.

Using Excel for problem creation also took a significant amount of time. A feature of Microsoft Word (Mail Merge) was used for some of the later problems to support and simplify formatting and coding. This procedure for Blackboard problem development cut the time required for the problem formatting by over 75%. The most time-consuming part of the process was creation of incorrect answers. Considerable time was invested in developing incorrect answers that were similar to correct answers, but not so similar as to be a second correct answer. We were unable to create a consistent methodology for creating these incorrect answers and ended up creating/editing them manually to ensure separation between answers.

Before and after retention data only exists for the Engineering Statics course. Before this project began, in over six previous semesters, covering eleven sections of the course taught by six different instructors, 13% of the students retook the class and 23% left engineering as a major. As of this writing, only two sections of Engineering Statics used the short videos produced by the project. Both of those sections were taught during the spring 2020 semester, which went fully online midway through the month of March due to the pandemic. One of the sections was an Honors course, and all 17 students have remained engineering majors. In the non-Honors section, 20 students were enrolled. Of those students, 3 left engineering and one retook the course. This sample size is obviously too small to draw any meaningful conclusions as to how well the pedagogical methods of the project affected student retention rates.

This type of learning system would seem ideal for an online course taught during a period of lockdown. However, we noticed that many students suffered from too much time in front of a computer screen, or zoom fatigue. After watching classes and holding meetings online, it was difficult for students to concentrate longer on doing problems and watching more videos on their computers.

Conclusions

For the Engineering Statics course, 49 videos were produced, and for the Introduction to Computer Science course, 32 videos were produced. Nineteen Statics students watched the videos with an average of 2.6 views per student, and 201 Introduction to Computer Science students watched their videos, with an average of 13.3 views per student.

Overall, the results suggest that the students were using the videos as supplemental material to help in areas that they were struggling. Self-reporting and the pattern of viewership supports the idea that in this role the videos were successful in helping the students master the course material. However, the videos were not generally used as preparatory material to watch before lecture - as would be done in a flipped classroom environment. Viewership was not regulated and was often sporadic. Most students were using video materials as reviews on an as-needed basis immediately before exams and homework. While the videos offered the opportunity to review lecture material that may have been missed, we conclude that creating a more fully flipped classroom, with more student participation during the face-to-face periods, will require directed video usage in advance. For example, online assessments/short assignments that are taken immediately upon completion of a video and with due dates that precede the lecture on the topic. It is recommended to keep video lengths as short as possible to maintain topic integrity. A data analysis of views per video length suggests that shorter videos are more likely to be viewed than longer videos.

Leveraging the results from our previous effort to use this method of course delivery, the process for generating randomized problems was refined. This allowed a large number of unique problems to be developed on specific topics, preventing students from cheating off each other or going online to find answers. We found that students were engaged in using these problems and assessments.

Moving forward, we see the benefit of embedding the assessments along with content delivery to provide real time feedback to students. The next generation learning system should be adaptive based on student performance from the data generated by the assessments. The benefits of the interactive system became evident through the exploration and testing of an online, interactive platform (VidGrid).

It is necessary to invest time into training faculty to use the recording facilities, and depending on the faculty, teaching styles may need to be adapted in order to become accustomed to using the video recording system. Faculty members can promote these videos and learning opportunities to their students to help improve understanding of particular topics. Once the video modules are recorded, time must be taken by the technical staff to produce good quality videos.

Finally, a more fully flipped classroom will require more direct mechanisms to get students to watch the videos in advance.

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