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A Pilot Study of an Online Accelerated Statics Course with Intensive Video Delivery

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A Qualitative Pilot Study of an Online Accelerated Statics Course with Intensive Video Delivery

Although online learning is extremely popular with 67 million of students taking online classes, it has not been widely used for extremely technical courses such as those in the field of engineering.[1] In order for optimal learning and transformation to occur, both the student and the professor must learn to evaluate the learning process differently. For the professor, this means examining what has traditionally been done in the past and what can be done in the future to enhance learning for all students. The traditional behaviorist model, which focuses on grades as a reward and punishment system, is no longer enough to ensure success of the majority of students in the educational environment today. Professors must evaluate techniques and methods that can assist in meeting the multiple learning styles of the students in their classes. For the student, transformation includes reflection, practice, and creating personal relevancy and meaning in the learning process. This is the framework of this pilot study on an online Engineering Statics class.

Literature Review

Online courses were created and deployed in numerous fields throughout the 1990s and 2000s. Online engineering courses lagged behind because of the difficulty of converting face-to-face mathematics and science courses to an online format.[1] The technology was not advanced enough to deploy these kinds of courses until the last few years. In addition, there is a definitive lack of engineering faculty who know how to teach online because it has not been done in the past. Teaching online, especially in a technical field such as engineering, is much different than teaching in the face-to-face classroom.

Lachiver & Tardif in 2002 noted during the 1990s that engineering education went through significant changes to meet the needs of the industry. At the beginning of the 21st century, Lachiver & Tarif called for innovative changes in engineering education. However, these changes impacted only face-to-face classrooms because this was the way almost all engineering courses were being offered at this time. The key changes Lachiver and Tarif identified were where, "each student learns though a personal construction of knowledge and competence that leads to him or her becoming an independent, self-governed learner".[2] The advent of advanced technology in the online format is precipitating another unprecedented change in engineering education in the second decade of the 21st century where this independent, self-governed learner no longer geographically has to reside on a physical campus. To do this "recontextualization"[2] Lachiver and Tarif recommended in certain engineering courses where hands on laboratories are not required, video methods can now easily be used to supplement the usual text-based online course.[2] In addition, other technologies such as Google Hangouts, Skype, and other applications allow students to cross geographic barriers and interact with faculty one-on-one or in groups much more freely and easily.

Lachiver and Tardif outlined four significant conditions that must occur for engineering curriculum change. The first is a strong leader the faculty respect. This leader must see and acknowledge the competing forces of engineering education history and the business decisions that must be made to solidify the future of the program. The second condition is to obtain a consensus that change is necessary; this is perhaps the most difficult step. The third step is to obtain consensus on the level of change, which can also be very difficult. Faculty opinions fall within all realms of the decision spectrum. Lachiver and Tarif stress the "transformation is much more ambitious and decidedly innovative."[2] The fourth condition is faculty must shift from a culture with a high degree of academic freedom to a high level of interdependence upon one another and the system around them. All faculty members must be able to assess what occurs in the global scheme and how they relate to it, as well as the effect the actions have on the whole university as well as their profession.[2]

Bourne, Harris and Mayado note for online engineering education to be broadly accepted and utilized: (1) the quality of online courses must be comparable to or better than the traditional classroom, (2) courses should be available when needed and accessible from anywhere by any number of learners, and (3) topics across the broad spectrum of engineering disciplines should be available."[3] Bourne et al. are all members of the Sloan Consortium, an organization that promotes education and best practices for online learning. They also note, "engineering has special needs when offered in a distance mode."[3] At the time they wrote this article, mathematics was not easy to deliver in the online format in a way that ensured students gained knowledge so it could be applied. This has changed in the almost nine years since this piece was written.

Bourne et al. also point out although it was possible to place some engineering classes online with available technology in 2005, the number of awarded engineering degrees that included online components had not significantly increased. They noted a distinct misconception that online education in engineering has to be self-paced without clear instructor guidance and little collaboration. With the technology available today, that is not the case. The authors also noted no significant differences have been found between online and on-campus students from 1992-2002 as reported by Moore in 2002 in the *Journal of Asynchronous Learning Networks*. Bourne et al.'s key point is the pedagogy must be examined and evaluated. If this is done properly, then online engineering education is possible because the addition of synchronous time in a course permits nearly the same level of interaction as in a typical classroom. They noted initial movement toward what is possible in the future starts with hybrid formats, then fully online courses and then fully online courses with laboratories. By doing this, institutions can increase their "breadth and scale."[3]

Stuart Palmer and Dale Holt in 2007 discussed the impact of Deakin University in Australia's institutional policy that each program must have an online course. At this time, Deakin offered an undergraduate engineering program on-campus, off campus and offshore. The course chosen by the engineering department was "Managing Industrial Organizations." Initially, students' ratings on the following two factors decreased: "this unit was well taught" and "I would recommend this unit to other students" when this class was put online. However, after additional discussion elements were added to the course, the ratings for these two factors returned to the same level it had been in face-to-face classes. Palmer and Holt's major finding was that a unit that is taught face-to-face cannot be directly converted to online delivery. The efficacy of class activities in the online setting must be evaluated and adjusted accordingly.[4]

In 2010, Jordan, Pakzad, and Oats surveyed engineering faculty and students to evaluate their perceptions of online courses in engineering. They found bias still exists against this type of education, primarily from faculty in regards to overall student performance; the perception is students perform better in the classroom. However, they noted online learning in engineering is a viable option that should be considered.[5]

Lim, Low, Attallah, Cheang, and LaBoone discussed the building of an engineering program for working adults at SIM University, an open university in Southeast Asia. This university successfully developed several completely online and hybrid courses in the Blackboard Learning System (LMS). The major benefit to this initiative has been the embedding of outcomes-based education in the programs with alignment of all course material in the program. In addition, through this program they are able to meet the needs of industry and all types of learners. Their goal is to have 50% of their courses online by 2015 (with synchronous and asynchronous components).[6]

Yang, Streveler, Miller, Slotta, Matusovich, and Magana in 2012 developed an online learning module to assist engineering students in learning heat transfer, mass diffusion, and microfluidics that was hosted in a learning management system. Students found this model extremely helpful in learning these technical concepts.[7] Dong, Lucey, and Leadbeater in 2012 performed a pilot study using Pearson "Mastering Engineering" online program and "Elluminate" synchronous sessions for their first year mechanical engineering students. They found online delivery greatly enhanced students' understanding of complex issues.[8] Green, Pinder-Grover, and Mirecki-Millunchick (2012) evaluated the efficacy of screencasts in undergraduate engineering. This screencasting consisted of a computer screen output with real time audio commentary. This study consisted of 262 students over two semesters; this was a 65% return rate. Fourteen of these students were in the mechanical engineering program; the remainder were in other engineering programs. Students who used these screencasts performed more effectively and reported favorable impression (90% positive) toward the screencasts. Students used the screencasts to study for exams (89%) and to assist with homework (29%). Approximately 33% of the students watched the videos from start to finish and 26% repeated certain segments. Screencasts were typically between 5 and 10 minutes. The researchers found a slightly positive correlation between screencast use and final exam performance.[9] Last, Sive and Sarma from the Massachusetts Institute of Technology (MIT) in 2013 noted with the advent of massively online open courses (MOOCs), online tools that can be used to teach engineering, can enrich the culture of a course.[10] In lieu of physical lecturing, professors can build an online course using the time they would have spent lecturing to create alternate ways of teaching the material.

Method Overview

This pilot study evaluates student perceptions of video use and satisfaction in an online eight-week accelerated engineering Statics class in the summer of 2013. The complete course was delivered online in a Blackboard LMS. Students were traditional undergraduate college students age 19-22 and were evaluated as an intact class in this pilot study. Approximately 83% were male and 17% were female. Traditional online course materials, such as a textbook, additional readings, homework practice and text-based materials were supplemented with numerous short videos created with an iPad and Doceri program. This program allowed the faculty member to discuss concepts, work example problems, and perform calculations directly in a video format.

This also enabled the students to visualize each step of the problem and the instructor was able to use various colors and highlighting features to demonstrate salient points. Student assessments were completed remotely and students submitted handwritten calculations for both tests and homework assignments through the course management system. Designated office hours were also held through video conferencing to ensure students received feedback and assistance and remained actively engaged in the coursework.

Twelve students were enrolled in the Statics course in this pilot study at a small private university in Texas that is well known for its traditional engineering programs. After the completion of the course, all students were invited to participate in a 20 item Likert-type survey with an additional three open-ended questions that assessed the overall content, format, instructional factors and particularly the video content. Semi-structured interviews were conducted and 58% of the students volunteered to participate in these interviews. Survey data was statistically analyzed and interview data was categorized according to prevalent themes and was triangulated with the survey data. In addition, an identical final exam was given to this group that had been given in the Fall 2012 semester for the traditional face-to-face course.

Course Design

The online Statics course was designed during the few months prior to the course. Several key goals for this course were established to ensure that a rigorous course was developed that met or exceeded expectations for a traditional, on-ground course:

1. The online course improves on the content from previous semesters
2. The online course uses technology effectively
3. The online course communicates the content in a way that students can understand and learn
4. The online course assesses students effectively

Since the online course was not restricted to a typical 50- or 75-minute lecture period, the content was organized based on course topics of varying lengths. The topic organization was intended to help students understand the content better by seeing the larger context for each lecture. The content was divided into twenty content topics based on previously-taught statics courses. The topics were delivered through the following components:

- **Video Lectures:** Video lectures (screencasts) were recorded by the instructor and focused on the theory, derivations, and big-picture concepts of a topic. These video lectures were typically less than ten minutes in length. Each topic contained approximately 1-3 lectures depending on the content of the topic.
- **Video Examples:** Each video lecture was accompanied by 1-3 example videos (screencasts) that provided an example of the content covered in the lecture. The examples typically ranged in length from a few minutes to 15 minutes. The examples were selected from the problems in the assigned textbook. During these example videos, students were encouraged at times to stop the video, work on the problem for a few minutes on their own, and resume the video to see the solution. An example of a video is shown in Figure 1.
- **Handouts:** The video lectures and examples included figures and procedures or other text that were overlaid with a tablet interface during the screencasts. These figures and text

were provided as PDF handouts to the students to allow them to follow along with the videos and take notes. See Figure 2 for an example of a handout.

- **Student Self-Assessments:** Each topic had a simple self-assessment at the end to help students determine if they were prepared to work the homework problems on their own. A simple problem and answer were provided to the students. See Figure 3 for an example of a self-assessment.
- **Homework Problems:** Approximately 4-8 homework problems were assigned for each content topic through an online homework system provided by the textbook publisher. Students were also required to submit hand-written solutions to approximately 30% of these problems to provide feedback on their problem-solving process and documentation. The written solutions were submitted electronically through the course management system.
- **Office Hours:** Synchronous office hours were held weekly during the course through a video chat system, where students had the opportunity to log into the office hours and ask questions. The instructor shared his screen with students and used a tablet interface to clarify concepts and answer questions about homework problems. In the format used for this course, all students could communicate with the professor simultaneously and hear other students' questions during these group office hours. Individual office hours were also held as needed using various formats such as video chat and phone calls.
- **Tests:** Students completed three written tests and a final exam. Tests were assigned as a PDF file through the course management system. Students were given approximately 75 minutes to download the test, complete it, and submit their numeric answers through the course management system. Students were then given approximately 30 additional minutes to submit their written work as a PDF or image file through the course management system. The numeric answers were not graded but were simply used to ensure that students did not continue working on the test during the time allotted for scanning the written work. Students also were required to have a trusted adult proctor the exam and both the student and proctor signed an academic integrity form. The proctor provided a telephone number so that the instructor could call with additional questions if necessary.

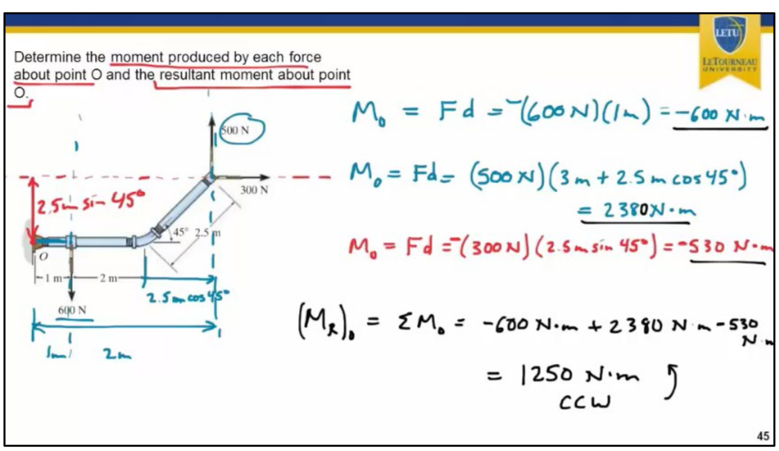

Figure 1: Image of an Example Video

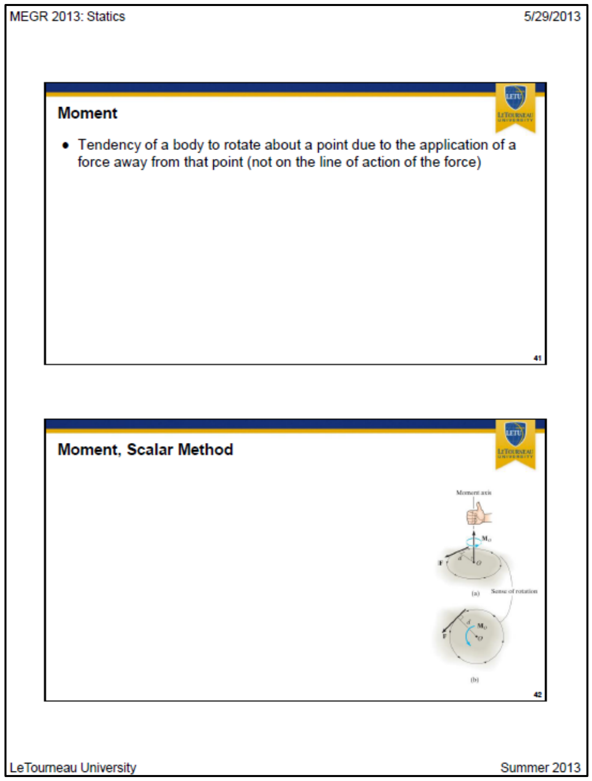

Figure 2: Image of a Handout Page Provided to Students for Note-taking

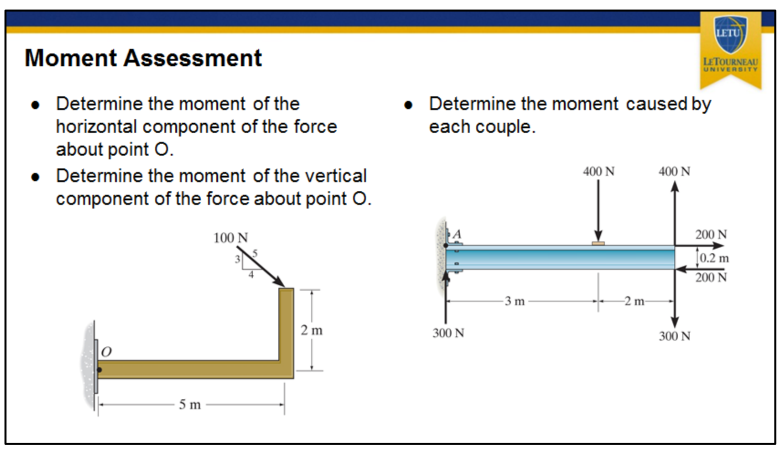

Figure 3: Image of a Self-Assessment Provided to Students

Results

Survey Results

All students who signed up for the course were asked to participate in an anonymous Likert-type survey to assess the summer Statics class; 6 of the original 12 students (50%) took this survey. Three students (25%) started the course but dropped it sometime throughout the semester. Results from several questions are shown in Table 1 and 2 below.

Table 1: Descriptive Statistics for Key Survey Elements

Item	Strongly Agree or Agree
Video lectures greatly assisted me in learning the course material	100%
Video examples greatly assisted me in learning the course material	100%
The videos were professionally made	100%

Table 2: Descriptive Statistics Key Survey Elements

Item	Strongly Disagree or Disagree	Neutral	Agree
Overall, I feel I would have learned more if I had taken this course in a traditional format (in a physical classroom)	50%	33%	17%

All students reported the videos enhanced their learning experience. The instructor created these videos with minimal assistance from the instructional technology and information technology departments. Assistance included set-up and lighting and very minimal video editing. Therefore, considerable production time was not required which reduced cost. However, the students still felt these videos were professionally done. Perhaps the most interesting finding in this survey is 50% of the students reported they preferred the online setting; 33% were neutral and reported they could take a class such as this in either modality. In essence, 83% of the students are open and accepting of taking an online engineering course in Statics. Only one student (17%) reported he/she would have learned more in a traditional classroom.

The survey also included three open-ended questions. Respondents estimated they watched, on the average, 99% or more of the lecture videos and 75-100% of the example videos. All students (100%) who responded listed flexibility as one of the major things they liked about the course. When queried about the things they did not like, all students noted the course was demanding, particularly in regards to homework, since it was an accelerated course.

The mean final exam scores of students in this this pilot study online group and students in the Fall 2012 face-to-face class were compared using a t test which yielded no significant differences ($p=0.445$, $p < .05$). Therefore, the online class final exam results were not significantly different from those in the previous face-to-face class.

Targeted Interview Results

Seven of the twelve (58%) students in this class agreed to participate in a semi-structured interview. This interview consisted of five questions with probes to elicit more detail. Since there were some students who were repeating the class because they had failed it the previous semester, two additional questions were included to solicit information on these repeating students. Three of the seven students (42%) were taking the course for the second time. Only one student failed the course a second time in the online format. This student acknowledged he/she did not put in the effort required to pass the course. One student who participated in the interview dropped the course.

Interviews were conducted by the co-researcher, who was not involved in class instruction, in September 2013 and responses were confidential. All students were queried about their use of the two types of videos in the online course: the lecture videos and the example videos.

Students were queried on how they used the videos in this online class. All (100%) of the students used the videos. All students viewed the lecture videos; however, one student noted, "I did not watch all of the videos in the beginning but by the second week I knew I had to watch them all." Seventy one percent of the students viewed all of the example videos; 29% only viewed them as they needed them. One of the two students that did not view the videos easily made an A in the course and did not need to use them; the other student was repeating the course and knew how to do several of the problem sets already. The slight variation in the results from the survey concerning this factor can stem from the fact the mix of students who took the survey and participated in the interviews could be different.

In the example videos the professor included stopping points where the students were directed to pause the video and work out the problem before going on to the next part of the lecture. None of the students (0%) used this feature except for one student who reporting doing it about "half the time." All other students fast forwarded through this section.

Overall, students reported the videos were well done; however, 29% felt the videos were too long. Although the example videos were short, the lecture videos were longer. Most students agreed the information in these longer videos was needed. One student reported using YouTube to fast forward through the videos at a higher speed.

The instructor also included online self-assessments so students could gain an idea of the actual knowledge they had gained; 71% of the students interviewed did not use this feature, 14.5% (1 student) used it and 14.5% (1 student) used some of the assessments. Because this course was conducted at a Christian university, the instructor also included optional online devotionals that students were encouraged to participate in. Five out of seven (71%) of the students interviewed did not participate in these devotionals. The reasons why they did not participate ranged from the length of time they had to devote to the course work to the summer full time employment they held to earn money for tuition.

Because of the nature of the course and the fact it was not feasible for the instructor to require all students to have an iPad and an application to submit calculations, the students were required to submit their handwritten homework assignments to the professor so he could check their procedure and not just their final answers. Some of the students (29%) felt submitting homework was somewhat cumbersome, one student (14%) thought it was very cumbersome and 57% had no problem submitting handwritten homework. For those that did have problems, it was because they did not have a smartphone or scanner available to them at all times since some also were on vacation. One student had some trouble because he had a broken arm and had to have his mother write out his assignments. All of the students (100%) noted the professor was flexible and accommodating regarding this issue.

Students were required to take their tests online in the Blackboard LMS and enter final answers only. This test was timed to ensure academic honesty. Immediately after completion of the test, the students were required to submit the handwritten papers with their work. This process was used to ensure test integrity. All students (100%) understood why it was required. One student felt "the online portion was pointless because it was not immediately graded" and would have preferred just to submit the handwritten work. This was not feasible because the test had to be timed to prevent the students from accessing additional sources. One student had a lightning strike that took out his power and ability to access test material but the instructor worked with the student.

All of the students (100%) acknowledged this course took a lot of time. One student reported that he/she spent at least three hours a day every day. However, they all also acknowledged this was what was required to truly learn Statics and be able to apply it in future classes.

Students were asked if they felt this class had any positive attributes; 100% of the students listed the videos as a definitive attribute that assisted their learning. In addition, 100% of the students (including the two students who had taken it in a traditional face-to-face environment) felt the videos would be an excellent addition to the face-to-face class to assist students who want more information or who are struggling. Many students reported they liked the flexibility of the course and the fact they could work and take the course simultaneously. Others liked the fact they could take statics by itself without the stressors of also taking an additional class load as they would had they taken it in the fall or spring semester. All of the students enjoyed the ability to view the videos over and over which they cannot do in the current face-to-face format. One student who had been diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) noted the videos accommodated his/her learning disability extremely well. All of the students also cited the provided video examples as a positive attribute of the course. One student noted it was "better than a textbook" and another noted, "it was as if he were in a face-to-face class."

Students were also asked about barriers to learning. One barrier noted by 29% of the students interviewed was a technology barrier. These students did not have smartphone technology, a fax machine or were not technologically savvy enough to figure out how to send in handwritten assignments. One student had a job in which he/she had to travel, which made submitting handwritten assignments difficult. However, the instructor worked with the student to overcome this barrier. One student reported that taking an online course was a barrier because this student likes the face-to-face experience and does not feel online courses are ideal for him/her. Because of this, the student fell behind in class and ended up dropping the course. This student noted the instructor offered to connect with him/her through Skype or some other mechanism but he/she did not accept the offer.

Students were also asked to suggest enhancements to the course. One student suggested the instructor consider time zones when the due dates are set. The student was in the Pacific time zone and felt that he/she had less time to work on tests that had to be taken on a specific day than the students in the Eastern or Central time zone. Two students (29%) wanted more timely or more detailed feedback, particularly on the tests. Another barrier noted by two students is the lack of peer-to-peer collaboration. They did not realize all students were able to "see" each other in the online classroom and could collaborate via email in the course but this capability was available.

When students were queried on if they would take another highly technical online course again, 6 out of 7 (85%) indicated they would. One student indicated it would depend on the professor. All of the students (100%) reported the course was very well done.

Discussion

The key finding in this pilot study is that an online course is a viable option for teaching Statics for undergraduate engineering students if the course is properly designed in a way that uses available technology tools to deliver learning that can approximate what is done in the face-to-face classroom. Significant time and attention must be devoted to create an engineering course in an online format as noted by Bourne et al.[3] in 2005. An online course can yield significant student satisfaction and provides students a way to gain education in the engineering field anywhere at any time. Students in this course found the video methods extremely effective as noted by Lachiver and Tardif [1], Jordan et al.[5], Sive and Sarma[10] and particularly Green et al.[9] Although technology has proliferated throughout society, particularly in regards to smart phone applications, technology barriers still existed in this group of students who grew up with technology. This barrier was specific to the use of productivity tools to return written documents to the professor.

Instructional technology, such as applications that allow professors to perform calculations step-by-step with audio voiceover, including the Doceri program used in this study very closely approximate what can be done in the face-to-face classroom in a way that can meet the needs of geographically separate learners. This is noted as a key factor by Bourne et al.[3], Palmer and Holt[4] and Lim et al.[6] However, at least the offer and scheduling of synchronous sessions where students can interact with each other and the instructor is optimal. In addition, one aspect students viewed somewhat negative in this course was lack of student-student collaboration although tools such as class email and discussions were available. Faculty can easily incorporate and educate students on the tools that are available. In addition, faculty can facilitate peer interaction through the use of chat rooms, instructor-led introductions and discussion posts, assignment of study groups, group projects, and other methods.

All of the students in this pilot study liked the use of instructional and example videos to help them address complex issues as noted by Yang et al.[7], Dong et al.[8] and Green et al.[9] Students also felt the videos would be a wonderful addition to a face-to-face class where they were hosted in a learning management system and would be available on demand. Students noted the lecture videos were long but acknowledged the material was needed. It would have been optimal if these lecture videos had been created in smaller 5-10 minute segments as noted by Green et al. [9] Another important finding is students can view videos as professionally made without extensive editing and production. This makes the use of this technology more cost effective for the program and the university. It is costly to create video and multimedia if students do not use it, but in this study all students engaged extensively with the videos provided.

A total of 50% of the students felt they would not have learned more in a face-to-face classroom and preferred delivery of the class online. This is a significant number because this was the first offering of the course. In addition, another 33% were neutral and considered it a viable option for learning in engineering in some subjects such as Statics. As Bourne et al. noted, the quality of online education must be just as good or better in the instruction in the face-to-face classroom and over half of the students reported they felt it was. Another important finding is that instructor flexibility is extremely important when attempting to provide technical courses online. In addition, there was no statistically significant differences in final exam scores when compared to a previous intact traditional face-to-face class taught at the university in Fall 2012, indicating that teaching Statics online is a viable option at this university.

Limitations and Recommendations

This study explored a small pilot group of students at one university in one class. All of the findings of this study may not be applicable to other engineering programs. In addition, students self-selected to participate in the survey or the interviews. This can result in the Hawthorne effect where people respond differently because they know they are being studied.

The primary recommendation of this study is creating online curriculum for a technical field such as engineering is a time consuming task; however, the time may be well spent since the material created can also be used as supplementary material in face-to-face classes. In this particular study, students as a whole did not utilize the self-assessments and did not stop the videos when they were directed to work on a mathematical calculation. Based on this small population, these techniques may not be effective delivery methods although they may be useful in other fields.

In regards to the video length, students prefer small video clips of about 5-10 minutes in length. Although they are likely to view longer clips in technical courses to gain the information, they may perceive them as too long and may fast forward through some of the material as well as some students did in this study. Although proctoring was not used for testing in this class because of cost, proctoring may be a viable option for testing for some institutions. This proctoring can be done in person or online where students have to perform the calculation and are videotaped by a webcam.

This course was an eight week accelerated course in Statics; however, this type of modality would also work well in a full semester class. An accelerated course may be appropriate for those students who are able to engage and devote the required hours to the course, advanced students, and students who need remedial assistance. However, the offering of this course in the summer allowed the students to take one class at a time and fully concentrate on a difficult subject.

Conclusion

Online learning is a viable method for engineering students at least in the teaching of Statics. Students enjoyed being able to freely view lecture material on demand and multiple times if needed, as well as the flexibility to take this course anywhere and do the work at any time. Overall, students perceived this online offering positively because it met their personal needs. One hundred percent of the students interviewed indicated videos were very helpful to their learning of Statics and felt these videos should also be used as supplementary material in a face-to-face class. Final exam score comparisons showed no statistically significant differences between the online class and the previous intact face-to-face class which supports the online modality as a valid method of teaching engineering Statics.

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