Exploring Video-Intensive Delivery in An Online and Face-to-Face Statics Course

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***Abstract-* Online learning has only taken hold in the engineering field within the last several years. Teaching engineering online is more problematic because of the technical nature of the field. This pilot study used qualitative research to evaluate student satisfaction with an eight-week accelerated statics class which used intensive lecture and sample problem videos and was taught during a summer session. Overall, students found the videos to be crucial to the online learning experience. Students also felt these videos would be helpful even if the course were completed in a traditional face-to face class. The final exam scores from a previous semester statics class taught by the primary researcher face-to-face was compared with a t test. There were no significant differences between students in the online course and in the face-to-face classroom. The next semester the videos were used in a control and experimental group model in two face-to-face classrooms. Overall, students in the experimental group performed better than those in the control group but the differences were not statistically significant. These findings indicate online learning can be a viable option in the teaching of undergraduate engineering statics.**

Index Terms- video demonstration; online engineering; video-intensive delivery; video lectures;

Introduction

Engineering students undergo a robust technically advanced education. Although over 6 million students participated in online learning in 2013, very few students took undergraduate engineering classes online [1]. At the time of this writing only one university, North Dakota State, had a comprehensive online undergraduate engineering program. Universities with traditional engineering programs are slowly testing the waters in regards to offering online engineering classes.

As technology advances and the pool of traditional students shrink, professors and students in all fields, including engineering, must learn to look at the learning process different. Professors need to consider that students in the 21st century may want to be educated in a different manner than students in the past. The traditional behavioral pedagogy model which uses grades as both punishment and reward is no longer sufficient to ensure the success of all students in the current educational environment. Professors must use techniques that enhance student learning and can meet the needs of multiple students, not just the high performers.

Students must learn to view education as a quest for true knowledge and experience and not just a quest for grades. Students need to transform from passive to active learners by being active participants in the educational process. In addition, they must learn how to create personal relevancy and meaning in the learning process. This is the framework of this pilot study.

I. LITERATURE REVIEW

Online courses became popular in the late 1990s and early 2000s in fields such as business and education where content was primarily didactic in nature and could be delivered by non-traditional means outside a face-to-face classroom. Classes in very technical fields, such as math, science and engineering, lagged behind because it was too difficult to convert these face-to-face classes into an online format successfully [1]. The technology that was available was not robust enough for courses that required extensive computation or laboratories. Initially these technologies were cost prohibitive, but in the second decade of the twenty first century, these technologies did become readily available. In addition, there was not a cadre of engineering faculty who had experience teaching in the online environment because it had not been done in the past. Online learning requires an intentional design and placing face-to-face curriculum online without considering the differences in delivery has been found to be a very ineffective way to deliver online education [2][3]. Teaching online, especially in a technical field such as engineering, is much different than teaching in the face-to-face classroom.

Engineering education underwent significant changes during the 1990's in an attempt to meet the changing needs of the industry. However, these changes only impacted the face-to-face classroom. Lachiver and Tarif in 2002 called for an engineering environment where, "each student learns though a personal construction of knowledge and competence that leads to him or her becoming an independent, self-governed learner"[4].Online education is precipitating another unprecedented change in engineering education in the second decade of the 21st century. More advanced technology has made delivery of engineering in the online format possible. This format can be beneficial for the independent, self-governed learner who does not desire to relocate to a physical campus. Lachiver and Tarif called these types of significant changes in engineering education “recontextualization”[4]. 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. 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.

According to Lachiver and Tarif there are four conditions that must occur in order to precipitate engineering curriculum change. First is the presence of a strong leader the other 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 required is a consensus among faculty that change is necessary. This can be the most challenging step since some faculty may be very resistant to change and may try to stop change from occurring. The next step is to obtain consensus on the level of change. This step may become even more complicated if technology is part of the proposed change. There are early adopters, mid-level and late adopters of technology. In addition, the culture of the organization will affect this process…is the organization one that takes risks or not? In the last step, 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 [4].

Bourne, Harris and Mayado also published criteria for broad faculty acceptance and utilization of online delivery in engineering education. The first is the quality of the online course must be as good as or better than what is given in the traditional face-to-face classroom. The second criteria is courses must be available where and when they are needed by learners. The last criteria is that several broad topics in engineering should be offered [5]. Bourne et al. were all members of the Sloan Consortium (now the Online 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 [5]. 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.

In 2005 Bourne et al. noted although it was possible to place some engineering classes online at that time, there were very few awarded engineering degrees that included any online components. In addition as technology became more advanced the number of schools offering online or hybrid courses did not increase significantly. Bourne et al noted one reason for this is because there was a misconception among faculty that online education had to be self-paced and would contain little or no collaboration. With the technology available today, this is definitely not the case. Online learning can be offered in a regular semester format with weekly assignments and synchronous activities. The authors also noted no significant differences had 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” [5].

By 2007, Deakin University in Australia offered undergraduate engineering courses on campus, in an off campus environment and offshore. Deakin mandated in institutional policy that each program must offer at least one online course. The course chosen by the engineering department was “Managing Industrial Organizations.” Initially, students’ ratings on the following two factors “this unit was well taught” and “I would recommend this unit to other students” decreased 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. Once crucial finding in this study was that a unit 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 [6].

As late as 2010, engineering faculty bias against online learning still was in existence according to Jordan, Pakzad, and Oats. The primary bias was that engineering faculty felt overall student performance could not be as good online as it is in the actual classroom with the instructor. However, they noted online learning in engineering is a viable option that should be considered [7].

An online engineering program was built for working adults at SIM university in Southeast Asia. Utilizing the

Blackboard learning management system, university faculty were able to successfully develop several online hybrid courses. According to Lim, Low, Attallah, Cheang, and LaBoone, the major benefit to this initiative was the embedding of outcomes-based education in the programs with alignment of all course material in the program. The authors reported this program has allowed them to meet the needs of industry as well as the learning needs of working adults. Their goal was to have 50% of their courses online by 2015 (with synchronous and asynchronous components) [8].

In 2013, Dong, Lucey, and Leadbeater [9] used Pearson's Mastering Engineering online program as well as synchronous online sessions to deliver courses for their first year mechanical engineering students.
They found online delivery greatly enhanced students' understanding of complex issues [8]. In 2012, Yang, Streveler, Miller, Slotta, Matusovich, and Magana used an online learning module for their students. This module covered heat transfer, microfluidics and mass diffusion. This module was also housed in a learning management system and it was rated as very helpful by the students who used it [10].

The efficacy of screencasts in undergraduate engineering was studied by Green, Pinder-Grover and Mirecki-Millunchick in 2012. The screencasts were between 5 and 10 minutes in length. The population of this study consisted of 262 students over a two semester time period. The return rate on the instrument used was 65%. The population consisted of students in various different types of engineering programs. The students used these screencasts for the following: studying for exams (89%) and assist with homework (29%). Thirty three percent of the students watched the videos from beginning to end while 26% viewed at least part of the screencasts multiple times. Ninety percent of the students that used the videos viewed them favorably. There was a slightly positive correlation between final exam scores and the use of the screencast [11].

In 2014 researchers at the Massachusetts Institute of Technology reported online learning methods should be used to enrich engineering courses and improve class culture. Sive and Sarma noted although detractors often complain about the time required to create a quality online quality course, the time spent building the courses is the same as the time that would be spent lecturing in the classroom [12].

II. METHOD OVERVIEW

An initial qualitative pilot study was conducted on a group of students in an eight week accelerate online statics course at a small private university with a large engineering school. The school of engineering comprised approximately one third of the residential population of about 1,400 students. In addition, this university also has approximately 1,400 students in online undergraduate and graduate programs primarily in business and education.

A semi-structured interview was created based on the findings in the literature and the research questions of interest. This interview was reviewed by experts in education as well as curriculum and online course design. The purpose of this interview was to gather rich data on students that attended the university's first ever online undergraduate engineering course regarding their satisfaction with and their perceptions of the video-intensive online course. The course was conducted in the summer of 2013 using the Blackboard 9.1 Learning Mamagement System. The course was designed by the instructor, a first year engineering professor.

The student population was all traditional undergraduate students between the ages of 19 and 22. Some of the students had failed their face-to-face and were repeating the course online during the summer semester. This group was evaluated as an intact clad and over 58% of the class participants agreed to be interviewed. The group was composed of a total of 12 students and was comprised of 83% males and 17% females. A textbook and other text-based materials were used in the online course including online readings and practice homework. These materials were supplemented with over 40 short video clips that provided brief lectures and samples of the instructor solving sample problems. The instructor use the software program Doceri and an Ipad to demonstrate sample problems in the video in real-time environment that closely approximated delivery in a classroom on a white board. 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. Students submitted their homework through the Blackboard system dropbox by scanning and uploading their written calculations. Students completed tests online but were required to immediately submit the handwritten to their solutions after completion of the test online. The instructor had a teaching assistant so graded assignments were returned promptly and students could learn from their errors. Designated office hours were also held through video conferencing to ensure students received feedback and assistance and remained actively engaged in the coursework. Students were given the same final exam that was administered by the instructor in his fall 2012 statics course; only the numbers in the problems were changed.

After the course was complete, the enrolled students (including those who had dropped the course) were solicited by the instructor to complete a questionnaire and participate in a 15 minute semi-structured interview conducted by the co-researcher. Half of the students completed a 20-item Likert survey after completing an informed consent where they rated their perceptions of the online statics course. This instrument also included three open-ended questions. All of the students were then contacted by the co-researcher and asked to participate in the interview; 58% of the students agreed to be interviewed and completed an additional informed consent so the identity of those who completed the survey would remain anonymous. Field notes from the interviews were compiled and qualitative interview data was analyzed by categorizing it according to prevalent themes. Survey quantitative data was calculated and triangulated to both the interview and open-ended question data. In addition the scores on the final exam were compared using a t test to the exam scores from the students in the survey data. In addition, the final exam scores from the online course were compared with the scores from the instructors fall 2012 statics course using a t test.

III. COURSE DESIGN

The online statics course was created by the instructor during the spring 2013 utilizing the assistance of an instructional technologist and curriculum specialist. 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. The goals were as follows:

- The online course would improve on the content from previous semesters.
- The online course would use technology effectively.
- The online course would communicate the content in a way that students could understand and learn.
- The online course would assess students effectively.

The design of the course was topical and not determined by chapter arrangement in the textbook. A total of 20 topics were included. This method was selected so students could get an overall understanding of important concepts since they would be completing the work on their own in the online format. The course as delivered using the following components:

- **Video Lectures:** The instructor recorded short video lecture vignettes. These lectures were typically less than 10 minutes in length. An overview of the most important concepts was included in the lecture. Each of the 20 topics in the course included between one and three video lectures.
- **Videos Demonstrations:** The instructor recorded video which showed step-by-step how to complete sample statics problems and calculations. These videos were completed using *Doceri* software. These length of these videos ranged from 1 to 16 minutes. The instructor included scheduled pauses in the videos where the students were prompted to work on their own solutions to the problem. The students could then resume viewing the video to check their work against the instructor's solution to the problem. 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:** Students were encouraged to do self-assessments throughout the course. Each of the 20 topic areas had a self-assessment to allow students to determine if they could work the problems on their own or required more study or instructor assistance. See Figure 3 for an example of a self-assessment.
- **Homework:** In this course homework was crucial to keep students on track and engaged in the course, particularly because the course was accelerated. Students were required to submit handwritten solutions and were awarded points for completing these assignments. The teaching assistant provides feedback to the students to improve performance. The handwritten solutions were scanned by the students and submitted through the Blackboard Learning Management System.
- **Office Hours:** The instructor held office hours weekly and encouraged students to interact with him and with one another. Adobe Connect Video chat was used since this program allowed the instructor to share his screen when demonstrating problems to the students in a synchronous environment. These office hours were held weekly. Students could also call or email the instructor at any time.
- **Assessments:** Three written exams were administered throughout the course. These tests were timed. Students took the text in the learning management system and were then required to submit a PDF file of their work to the instructor within 30 minutes of completing the test. The workaround was used since the instructor did not want to require students to purchase Ipads and the Doceri program although this would have facilitated this process. The instructor collated the

answers online in the timed test with the handwritten work during the grading process. In addition, students had to arrange for a proctor who could observe them taking the test to deter academic dishonesty. The proctor also signed a form stating he/she would only allow the student to work during the allotted time period and would ensure students did not attempt to go to other websites or use materials other than what was provided for the test.

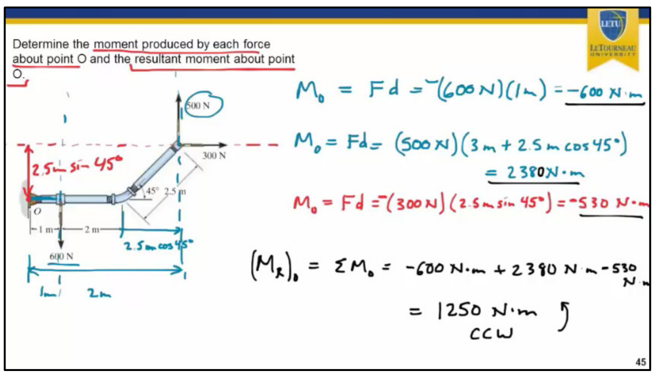

Figure 1: Image of an Example Video

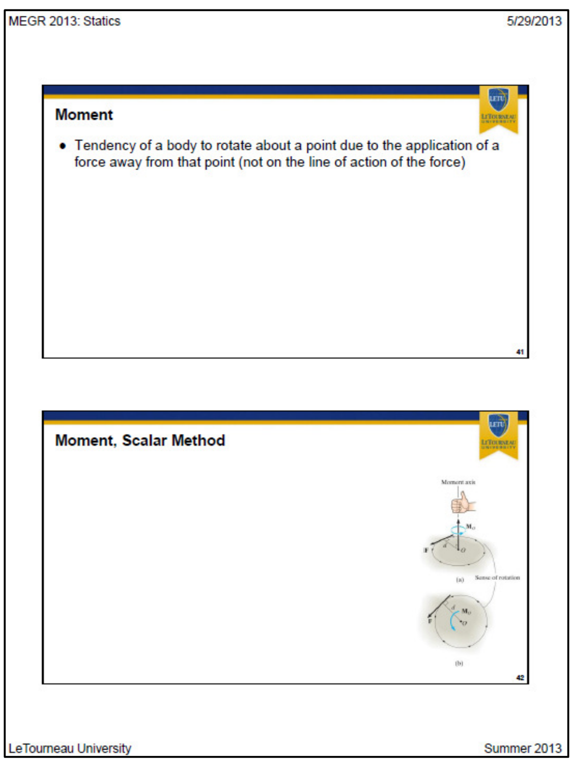

Figure 2: Image of a Handout Page Provided to Students for Note-taking

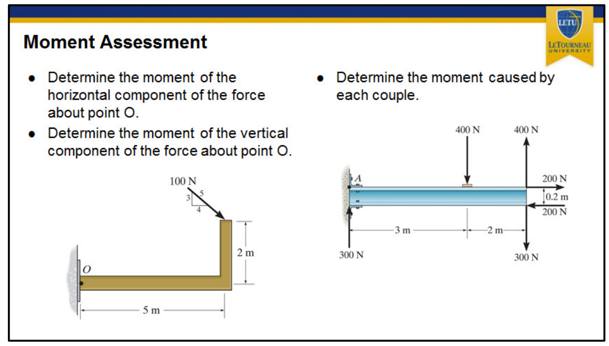

Figure 3: Image of a Self-Assessment Provided to Students

IV. RESULTS

A. Survey Results

Although 12 students started the statics course, only nine students completed it. Of the nine that completed the course, six (67%) completed the anonymous survey. Results from several questions are shown in Table 1.0 and 2.0.

One hundred percent of the students agreed or strongly agreed the video lectures and demonstrations enhanced the online learning experience. Although very minimal editing was done on the videos due to time, staff and cost restraints, students still agreed the videos looked professionally done. Two thirds of the nine students (67%) reported they preferred completing this course in the online over the face-to-face format for this course. Two students selected the neutral response indicating they had not preference and would take the class in either format. Only one of the students would have preferred taking the class face-to-face.

Overall, 88% of the students are open and accepting of taking an online engineering course in Statics.

Table 1.0: Descriptive Statistics for Key Survey Elements

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

Table 2.0: Descriptive Statistics Key Survey Elements

ITEM	Strongly Agree/Agree	Neutral	Strongly Disagree/Disagree
Overall, I feel I would have learned more if I had taken this course in a traditional format (in a physical classroom)	11%	22%	67%

The open-ended questions queried the students on how often they used the lecture and demonstration videos. Respondents reported they watched 99 or more of the lecture videos and anywhere from 75-100% of demonstration videos. One hundred percent of the students listed the flexible nature of the course in the online format as the number one thing they liked about this course. When queried as to what they did not like, students indicated the course was very demanding and had a lot of homework to complete.

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 ($t=0.90$, $p=0.38$). Therefore, the online class final exam results were not significantly different from those in the previous face-to-face class.

B. Results Targeted Interviews

Seven of the nine students that completed the class agreed to participate in a semi-structured interview conducted by the co-researcher who was not a faculty member in the engineering school. Since some students were repeating the course two additional questions were included for three students (33%) to solicit information since they had taken the course in both the online and face-to-face formats. The portion of the interview completed by all participants consisted of five questions with probes to elicit more detail. 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 in September 2013 and focused on student perceptions and use of the lecture and demonstration videos.

In the interview, 100% of students reported they used the videos in the course. Although 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. Students were queried as to if they followed the directions in the demonstration videos and paused the video and attempted to solve the problem before viewing the solution. 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 info 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.

Some of the students (29%) felt submitting homework was somewhat cumbersome, one student (14%) thought it was very cumbersome;57% had no problem submitting handwritten homework. For those that did have problems, they 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.

When students were queried about the testing procedures, all of them understood why the procedures used to ensure academic integrity were used. 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.

Students overall felt this was a very time-consuming course. 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 to list the positive attributes in this course. All (100%) if the students listed the videos as a positive attribute that increased their learning and knowledge in statics. 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.”

During the interview process, students were also queried about barriers to learning in the course. Technology barriers were cited by 29% of the students that were interviewed. These students noted they did not have smart technologies or a fax machine and they 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 liked the face-to-face experience and did 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 queried on what they thought could be done to improve the course. One student suggested that the due dates in the course include the time zones since the students were dispersed all over the United States. 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. The instructor did not set up a student lounge discussion forum. 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.

V. DISCUSSION

This pilot study demonstrates that at least in this private university undergraduate population, the online format was a viable option for teaching statics to engineering student. A crucial component is the course must be designed specifically for online delivery/ By using technology tools that are cost effective and readily available, an instructor can deliver learning that closely matches what is done in the face-to-face classroom. This course required significant development time, attention and resources as noted by Bourne et al. [3] in 2005. The use of intensive video in this course was found to be an effective way for students to learn the material in the online format. This finding supports Lachiver and Tardif [4] , Jordan et al. [7], Sive and Sarma [12]and particularly Green et al.’s [11] findings. 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* software 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. [5], Palmer and Holt [6] and Lim et al. [8]. However, even though the online format is primarily asynchronous, synchronous sessions allow the students to connect with one another and with the instructor. The number one aspect of online student satisfaction is engagement [13] [14]. Students in this course would have liked to have student-student collaboration. Although tools such as class email and discussions were available, the instructor did not use them or set up a student lounge discussion forum. As long as technology is not overused and students spend more time trying to understand how to use the technology rather than learning content, 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.

The findings of this study supported Yang et al., [10] Dong et al. [9] and Green et al.'s [11] assertion that video can be used to address complex problems and issues. Students in this population recommended the videos be incorporated into future face-to-face classes to enhance student learning. Some of the videos in this course were longer than the 5-10 minutes recommended by Green et al. [11]; however, because of the topic, the students felt the additional length was warranted. An improvement that can be made to this course is to break down the longer videos into shorter sessions no more than 10 minutes in length. An important finding is that the students in this population still did view the videos as professionally made even though they were made in an expedient and cost effective manner with little editing. Since this was a pilot study, extensive editing was not done. However, since it is costly for schools to create professional studio quality video, this can be a financial risk if students do not use the product.

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. [5] 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. 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.

A. Further Research in the Face-to-Face Classroom Fall 2013

In fall of 2013, the researchers conducted a quasi-experimental analysis of the perceived effectiveness of the same videos in face-to-face classes at the same university. One group was randomly selected as the control group and the other as the experimental group. Students self-selected into each of the classes through the class scheduling process. The primary research taught both of these face-to-face classes. The control group only received the usual face-to-face lectures. The experimental group was given access to the lecture and demonstration videos from the online course. These lectures served as supplementary material. This was done in accordance with Ruthven [15], Day et al. [16] and to Jordan, Pakzad and Oats' [17] recommendations that multimedia and supplementary video are effective in technical demanding courses.

The mean scores of all four tests in these two full semester face-to-face statics courses were compared using a t test individually and together ($t = -0.31$, $p = 0.76$); the t test was not statistically significant. However, the overall means for the experimental group that had access to the supplementary videos was very slightly higher than the experimental group ($M = 80.05$ versus $M = 79.06$). However, this could be caused by group variation. Students in the experimental group were less likely to review their assigned material before coming to class, most likely because they could review the material in video form at their leisure. However, this could result in students not being prepared for class. Although it was not statistically significant, the means of the students in the experimental group in response to "The course materials provided assisted me in better learning the concepts of the class" were higher (M =4.60) versus the mean of the control group (M =3.33)

B. Limitations and Recommendations

Although the findings of this research cannot be generalized beyond this population, because of the small population size, it does contribute to the growing body of engineering education literature, particularly in regards to online modalities. The research took place at a small private university in the south and the findings may not be applicable to other engineering programs. This was a cluster sample; students were not randomly selected to participate in the interviews. Because of the small class size, the researchers tried to interview as many students as possible. Since self-report instruments were used, this can result in the Hawthorne effect where people respond differently because they know they are being studied.

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.

Were this study methodology to be replicated, the videos that would be created should have a maximum length of 5-10 minutes. Although the students in this population still viewed the longer videos, all student populations may not and the video production time and cost could be wasted.

Online proctoring tools such as Respondus Browser (which locks the student from accessing additional sites online while testing) and Respondus Monitor, and electronic proctoring program, may provide more effective testing techniques than those used in this study. Electronic proctoring programs videotape the student as he/she is taking the test so academic integrity can be assured. These types of technologies were not used because they were cost prohibitive in this study.

Although this research looked at an eight week accelerated course, this method would also work well in a full semester class in statics or other subjects in engineering that do not require hand-on laboratories. If hands on laboratories are required, this method could also be used to create the online portion of a hybrid course. However, offering this course in the summer allowed the students to take one class at a time and fully concentrate on a difficult subject.

C. Recommendations for Further Research

Research in online engineering education is in its infancy currently. This area is ripe for additional research studies in varying topic areas. Qualitative research which evaluates student perceptions can be helpful in gaining a deeper understanding of the efficacy of online engineering in various subject areas. In addition, quantitative studies on larger research populations will supply additional data that can be generalized to multiple populations.

Conclusion

Online learning can be a viable method for the teaching of statics in an undergraduate engineering program, at least in more fundamental courses. The students in this study actively used the provided lecture and demonstration videos. 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. Using a control and experimental group, these videos were found to be useful by students in a face-to-face class at the same university. 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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