Are Online Courses Appropriate for Engineering Classes?

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Abstract
Many people in higher education are looking to online courses to ease a space and time crunch. But what kind of courses can be adequately taught online? Can a quantitative engineering course be taught successfully online and if so, what is the best format? In order to provide insight into these questions, I have developed and taught an online Statics course for engineering, construction management, and architecture majors. After offering this course and a face-to-face version simultaneously, I have found that there are significant advantages to an online course that a traditional face-to-face course does not enjoy. In fact, the online offering has been more successful than the face-to-face for some students because of the ease in appealing to different learning styles. In addition, lessons learned through developing an online course have been applied to enhance the face-to-face course.

Introduction
I was asked to develop an online course in Statics in order to help alleviate the lack of classroom space and time in student's schedules. But, like many traditional engineering faculty members, I was resistant to offering engineering courses online. I was concerned that students would have a hard time learning challenging material if they were not meeting me in-person. My goal was to develop not just an adequate online course, but to use the vast technological resources available to create a great online course. How successful this was course surprised me and more surprising was how I found myself improving my face-to-face courses through incorporation of some online techniques.

Online Course Overview
In order to explore the possibility of online delivery for an engineering course, I chose a standard Statics course which is a basic course in any engineering program. At Roger Williams University, Statics is taught as a 3 credit course for engineering, architecture, and construction management students. The prerequisite is one semester of calculus. The course has a required textbook and is assessed using graded homework assignments, a project, three exams, and a final exam.

The online course is delivered as a hybrid: the lessons are conducted asynchronously, but office hours and exams are synchronous. I have offered the online course during two semesters so far: I taught one section online in the winter intersession which ran for 6 weeks, starting right after final exams. I also taught the online course during the regular 14 week semester. This is important to note because the success of the online course had much to do with when the students took it, as noted below.

Overall, the online course was organized exactly like the face-to-face sections. The major difference was that instead of dividing the course into 28 lessons as in the two

times per week offering, I divided the online course up into 10 units, based on course content. For each unit, students were required to watch lesson videos that I prepared, to read the assigned sections in the textbook, and to complete a homework assignment. Assignments were completed on paper, scanned to PDF, and submitted online through Blackboard. I would promptly grade and comment on each submission. Solutions to the homework were posted after the assignment was graded, so that students could see how to fix their mistakes. Every three lessons, an exam was administered to measure student learning. To help study, sample exams were posted online along with videos showing the solution. For the winter course, because students were scattered across the country, exams were given by a proctor that the student had identified then scanned and submitted by email or Blackboard. During the regular semester, all the students were on campus and therefore, came in to the classroom to take the exams.

Recognizing that the lesson delivery would be crucial to the success of the online course, I spent considerable time in developing a way to convey the information while also engaging the students. For this course, I needed to teach problem-solving, not memorization and so I realized that typing out power point slides and having students read the text would not be adequate for this course. I needed a much more active and participatory mode of delivery.

What I really wanted was for the online version to be as similar as possible to the face-to-face version, and so I tried to replicate the in-class experience. But simply using a video of me teaching was almost as un-engaging as presentation slides. I concluded that the students needed to hear my explanations and to see my writing and drawing on the chalk/white board. To accomplish this, I used a tablet and recording software, and went through each lesson as if I were in the classroom, writing with the stylus on my tablet, via Microsoft One-Note, and talking into a microphone. In order to keep the file size within reasonable limits, I broke up each lesson into three or four videos, each 15-20 minutes in length, ending up with about 10 MB MP4 files.

When the video files are played, the student can use the standard playback controls, such as pause, rewind, and fast forward. The students would watch me writing on the “board” and hear me speaking. The intent was to have students take notes from the lessons, just as they would in class. They should also be doing the calculations and solving the example problems with me. At any time during playback, the video could be paused or rewound to repeat. Shown in Figure 1 is a snapshot of a lesson video on 2-dimensional equilibrium. Color is used very successfully for clarity, especially in the drawings. In addition, the page can be set up prior to recording, with pictures, videos, typed text, etc.

The biggest difference between the online and face-to-face delivery was the access to the instructor to ask questions and get further explanations. This was partially solved during the intersession offering by conducting synchronous virtual office hours using Illuminate. During the regular semester, in person office hours were available. However, having taught this course many times, I have predicted many of the questions and addressed those concerns in the videos.

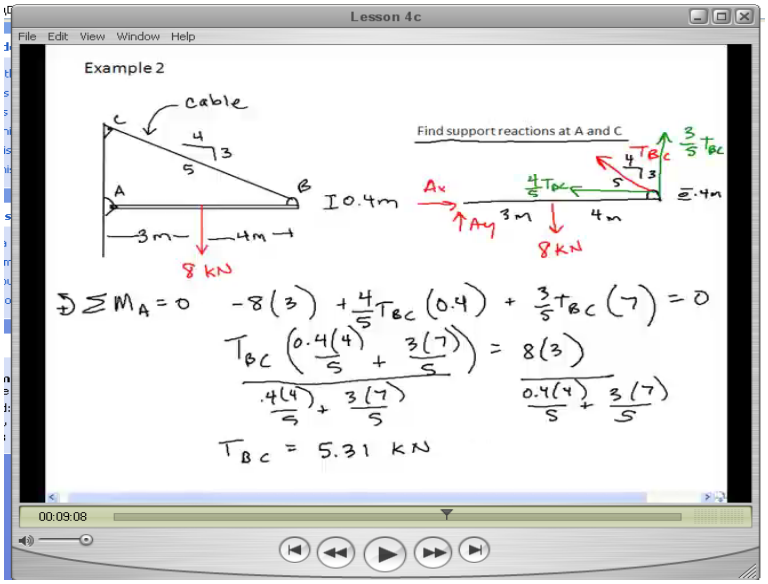

Figure 1: Snapshot of lesson video

Lessons Learned

The course was generally successful, but more successful during the intersession than the regular semester. The students in the intersession were only taking this course and found that working on the material every day helped them really learn it. The students during the regular semester on the other hand, were fitting this course in along with four others. These students tended to have not as much time to work on the course and therefore, not as much engagement in the course. As expected, motivation of the students was critical in their success. The students taking the online course because they thought that all online courses were easy, found themselves quickly underwater.

In addition to the motivation of the student as factors for the success, I found that learning style also was an important factor. The online course had the benefit of being able to pause and rewind the lesson video. For some students, being able to watch the lesson over again helped tremendously. In fact, one student who failed the course during the regular semester retook the course during the intersession and earned an A. He attributes the improvement to being able to go at his own pace and not having to rush through to following along in class.

There are many advantages to online delivery as well as disadvantages. In table 1, I have listed the most important advantages and disadvantages that I have found in developing and delivering an engineering online course. This list is not exhaustive, but represents my experience. One important advantage was that it was very easy to add technological enhancements to the lessons, such as video simulations, pictures, links, and other videos. This helps to create an engaging and clear lesson. Of course, an instructor can and should include these in a regular class, but the way I have set up the online course, it was effortless and really enhanced the material.

Table 1: Some Advantages and Disadvantages to Online Delivery

Advantages to Online Delivery	Disadvantages to Online Delivery
Students can watch the videos at their own pace	Requires student motivation
Flexibility in student scheduling	Considerable up-front time required of instructor
Can add wide variety of technology to lesson videos and documents	Not as much direct contact with students

Enhance Face-to-Face Experience

After having spent the time to develop the online course, I found myself using some of the tools to enhance my face-to-face courses as well. For example, the lesson videos can be used to illustrate more example problems when there was insufficient time in class. I found the videos especially useful for reviewing material for exams: students could work on a sample exam then watch the video solution for help in solving the problems. I also used the videos to review some math concepts that were important for the course, but that all students should have seen before. And finally, the lessons can be used as a substitution for in-class time when I was unavailable for class.

Conclusions

At the end of the semester, the same final exam was administered to the online and face-to-face sections. The average grade for each section was comparable, indicating a similar level of learning for each delivery method. Of course, the students were self-selected into the online course, and thus the samples for each section were not random. Therefore the results do not definitively prove the lack of difference between the delivery methods, but it does support the continued offering of the online course.