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Teaching Numerical Methods in an Online Asynchronous Format

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In the middle of the spring semester of 2020, all faculty at our university had to switch our courses to online instruction due to the COVID-19 pandemic. I was teaching both the sections of 317 - Numerical Methods. I chose the asynchronous mode to teach the course online whereas almost all faculty in my department chose the synchronous mode using the Zoom Video Conferencing software. I chose the asynchronous mode because neither I nor my students have adequate hardware or network access for a decent synchronous communication.

This paper describes how I taught the course online asynchronously in the spring semester using a SmartPen, and the associated labs using videos produced with the Camtasia software. It details changes I made in the following fall semester to create lecture videos using Camtasia, and integrating PowerPoint slides with narrated board-work using a document camera. The paper concludes with lessons learned, and provides recommendations for the future when we return to normal in-person instruction.

317 – Numerical Methods is a three semester credit course that, until recently, was a required course for all mechanical engineering students at our university [1]. 317 has been replaced as a required course by 117 – Introduction to Programming for Engineers, and is now an applied elective course. 317 focuses on numerical methods to (i) solve a system of linear or non-linear equations, (ii) fit a linearized fitting function, (iii) numerically evaluate a definite proper integral, (iv) numerically evaluate derivatives of a function, (v) solve a system of ordinary differential equations – initial value problem, and (vi) solve a 2^{nd} order ordinary differential equation – boundary value problem; with numerical analysis to understand errors, error bounds, convergence criteria and conditions, and relative stability of a method.

In a traditional semester, the course consists of two classes of 50 minutes each and a lab of 50 minutes every week for 14 weeks, followed by a final exam period. Typically, each week runs from Monday to Friday, and accordingly, classes are on Mondays and Wednesdays, and labs on Fridays. Nominal section size is 45 students with one lab teaching assistant per fifteen students.

After each of the two weekly classes, students take an online quiz consisting of ten questions with four possible answers. The best of three possible attempts is counted towards the final grade. The intent of these online quizzes is for students to master the fundamental concepts, and understand a numerical algorithm by performing it manually. Each quiz is due before the next class. This ensures that each student has learned the previous class material. When students complete every course assignment conscientiously, they become proficient in the topics, and the course learning outcomes are achieved.

In the lab each week, students implement one or more numerical methods using Excel and VBA to solve a real-world problem. Students bring an Excel template that they have created given a PDF form of the Excel template. The instructor provides step-by-step instructions to do the lab. Teaching assistants are available to help students and also grade the lab reports according to a detailed grading rubric. Two mid-term tests are held during the sixth and the eleventh lab in addition to a final exam. Thus, the final grade is based on 22 quizzes (1% each), 12 labs (2% each), and three tests (18% each).

When I pivoted to asynchronous mode in Spring 2020, I created video lectures in the form of Pencasts using a SmartPen [2]. Five lab videos were created using Camtasia. Camtasia is a software to create, record, and edit presentations on a computer screen. In each video, the screen consisted of a PowerPoint slide in “reader view” on the left side of the screen and an Excel spreadsheet on the right side of the screen. Each slide had step-by-step instructions to implement a numerical method with the Excel worksheet image showing the implementation in intermediate stages. The recording consisted of inset window of the instructor narrating the implementation of the method. The lab videos were uploaded to YouTube in the MP4 file format. YouTube Studio does automatic captioning with remarkable accuracy during the conversion to the high definition (HD) format. Many students and the three lab assistants told me that the lab videos were much more useful and effective than my in-person lab tutorials before the spring break.

Students took their second mid-term test and the final exam online synchronously under closed-book and closed-notes condition with our university’s honor pledge to not cheat. For each exam, they were provided a formula

sheet. Each exam had around 36 multiple-choice questions that were similar to the online quizzes. End of the semester student ratings of the course indicate that both the lecture and the lab instruction were very effective.

In late summer 2020, the university offered every faculty a choice among four technology packages consisting of a document camera and peripheral audio-video equipment to assist in various modalities of instruction. In fall 2020, I taught the only section of 317 offered. Since the lab videos created in the spring 2020 were very successful, I created a new set of twelve lab videos using Camtasia to record side-by-side screens of PowerPoint slides containing instructions and Excel step-by-step narrated demonstrations. Each lab had a detailed grading rubric.

For the class component of the course, I created 24 video lectures using Camtasia to record side-by-side screens of PowerPoint slides and document camera showing my narrated board work on a lined writing pad with an ordinary pen. Each video was uploaded to YouTube with a link listed in MyCourses. Again, I found that the YouTube Studio does automatic captioning with remarkable accuracy during the conversion to the high definition (HD) format.

Creating both lab and lecture videos required a lot of time compared to in-person teaching. While supplementary PowerPoint slides were easily refined from the previous academic term, recording each video and editing it using Camtasia, converting the recording to MP4, and then uploading it to YouTube Studio was quite time intensive.

Since I had limited interaction with students, I created a survey consisting of nine multiple choice questions and an open ended question that was administered after three weeks of instruction, and was worth 1% of grade. Survey responses were overwhelmingly positive with the majority of students reporting that they felt the course objectives were fulfilled and that the course content was presented effectively and clearly. Student ratings of the course at the end of the semester also indicated that that both the lecture and lab instruction done online asynchronously were very effective.

Concluding Remarks

In spring 2020, the pivot to online asynchronous instruction by replacing in-person lectures by Pencasts using a SmartPen was very effective. However, the Pencasts could not be integrated easily with the accompanying PowerPoint slides. Five lab videos were created using Camtasia in conjunction with PowerPoint slides, and Excel step by step instructions and demonstration. Students and the lab assistants found the lab videos to be very effective.

In fall 2020, twenty two lecture videos were created using Camtasia in conjunction with PowerPoint slides and board work using a document camera. Although it took a long time to create each lecture video, I was pleased when students found them to be quite effective. Twelve lab videos were created using Camtasia in conjunction with PowerPoint slides, and Excel step by step instructions and demonstration. Creating each lab video was also a time consuming process.

Lecture and lab videos were uploaded to YouTube with a link listed in MyCourses. I found that the YouTube Studio does automatic captioning with remarkable accuracy during the conversion to the high definition (HD) format. When we return to in-person instruction, I will replace the in-person lab instruction by lab videos. Lab assistants will be available in the Friday labs to assist. For students looking for a challenge, I will use the lab time for an optional class to teach numerical modeling.

References

1. S. K. Gupta, *Innovations in the "Computational Methods" Course Sequence*, The ASME 1996 Curriculum Innovation Awards, The American Society of Mechanical Engineers, (1996)20-22.
2. S. K. Gupta, *Supplementing Instruction with Pencasts Created with a SmartPen,* Proceedings of the 2013 ASEE Annual Conference in Atlanta, GA (June 2013).