Assessing the Efficacy of Supplemental Online Lecture Modules in a Core Mechanical Engineering Undergraduate Course

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Abstract

In this paper, we report on a research study performed in a core, 2nd year mechanical engineering class, “Computing Tools for Engineering Design”, where lectures were available to all students both in-person and as a video recording of the same lecture. On exams and quizzes each student was asked how they prepared for each test: did they prepare by use of in-person lectures, online lectures, a combination of both or neither? We then compared how each method of course delivery used by a student with the resulting grade on the quiz/exam. This information was used to determine if the mode of lecture delivery (in-class or online) impacted students’ performance on examinations.

1. Introduction

Although distance learning and video lectures have been available for the past 50 years (e.g., Open University[1]), recent advances in video and online technology along with decreasing cost of this technology, have made this approach much more accessible to teaching faculty. This has opened up the possibility of adding an alternative instructional delivery method, like a video lecture, to increase accessibility to lecture content by reaching students who were unable to attend in-person lectures, and allowing students to re-watch lectures and learn at their own pace on demand.

Despite the increased accessibility to lecture content that video lectures can provide, this approach can be intimidating for educators who want to try new lecture-delivery techniques. For example, does a professor really have to use the latest, and newest educational technology to transform their lectures for online/video delivery? Or can it be as simple as recording a video version of the exact lecture that students in a classroom would receive? If low-tech video lecture recordings are just as effective as in-person lectures, the barriers of entry for instructors to add this resource to the classroom could be less intimidating.

In this paper, we present a study to address these questions, as well as investigate the impact of supplemental video lectures on student learning. We begin with a brief overview of recent work in the area of online and hybrid learning, then describe our study in Sections 2 and 3 respectively. Next, we present the results of our study in Section 4, then conclude with a brief description of our future work in this area.

2. Online and hybrid education

Recent interest in online and hybrid (i.e., combining online and classroom instruction[2]) learning has generated extensive discussion of the benefits[3] as well as the risks[4] of these new approaches in the literature. Arguably, the most famous contribution to this area in recent years has been the “massive open online course” or MOOC[5], where students view relatively traditional lectures by a prestigious professor through an online forum (a good example of this approach is Harvard’s introductory computer science course “CS 50”).

Although online delivery has generated much interest in higher education, institutions struggle with its implementation[6]. As well, it is not clear that this single technological solution (online lectures) is warranted: particularly, in disciplines such as engineering where in-person activities such as project-based learning and laboratories are necessary. As a result, there has been interest in hybrid learning techniques such as “flipped” learning[7] where online lectures are used to open-up time for more meaningful activities in the in-person sessions (e.g., discussions, case studies, projects, problem solving sessions, etc.). Arguably, the flipped approach does not require an online component – as Cussler[8] notes, “flipped” has existed for many years in the form of out of class preparation (e.g., reading a play prior to class) – but recording lectures for students prior to class, does provide a convenient way to free up the in-class time for other activities.

The verdict is still out on the benefits of online learning. However, there does appear to be growing consensus that online learning in isolation can be problematic with respect to student completion and student assessment[9]; but when online learning is combined with face-to-face activities, students can learn even more than in traditional or purely online approaches[2,10].

3. Design of the study

3.1 Second-year computing tools for engineering design

Following research ethics board approval, this study was conducted in the Fall 2015 term in the Schulich School of Engineering second year course, Mechanical Engineering 337 “Computing Tools for Engineering Design” – at the University of Calgary, Canada. This course is a continuation of the first-year computing course, Engineering 233 “Computing for Engineers”, where students are introduced to computer systems and programming in a high-level language (Java[11]). The goal of this second-year course is to provide students with experience in applying high-level software (in this case, MATLAB[12]) to the solution of mechanical engineering design problems.

Since its introduction into the B.Sc. in Mechanical Engineering curriculum, “Computing Tools for Engineering Design” has been taught in the traditional fashion of 3 hours of lectures per week, with a single 3-hour laboratory every week. Presently, the course is offered each Fall term (September to December) to approximately 200 second-year students, who are divided into 2 lecture cohorts of approximately 100 students and 6 laboratory cohorts of approximately 33 students.

For the Fall 2015 offering, the course instructor for one of the two sections recorded videos of every lecture and posted these videos each day on the course’s learning management system. These videos were taken using a simple web-camera from the front row of the lecture theatre, and were uploaded to the learning management system in an unedited format. The intention was to provide a simple “facsimile” of the lecture for students to use in-lieu of attending the lectures, or as a review of the lecture. It should be noted that the videos were not intended to replace the in-class lectures, but rather, to provide an additional resource for students to support their learning.

3.2 The classroom survey

The method used to determine if the supplemental video lectures enhanced student performance involved administering a very simple survey – in the form of a single question – at the end of each quiz:

> Which of the following best describes how you prepared for this quiz?
>
> > a) I prepared primarily using class lectures.
> >
> > b) I prepared primarily using the video lectures.
> >
> > c) I prepared using a combination of class lectures and video lectures.
> >
> > d) I prepared primarily without using class lectures or video lectures.

A total of five quizzes were given in the course, beginning with three quizzes on the MATLAB, then concluding with two quizzes on LabVIEW:

> Quiz 1 - Introduction to MATLAB, defining variables, and creating arrays.
>
> Quiz 2 - Mathematical operations with arrays, managing data, and script files.
>
> Quiz 3 - 2D plotting, Boolean logic, conditional structures, and looping structures.
>
> Quiz 4 - Creating user defined functions, polynomials, curve fitting, numerical analysis, and solving ODEs numerically.
>
> Quiz 5 - LabVIEW introduction, looping structures, plotting tools, mathematical operations, and Boolean logic.

3.3 Research question

In order to investigate the effect of the supplemental videos on student achievement in "Computing Tools for Engineering Design", we explored the following research question:

> *Does the mode of lecture delivery (in-class or online) impact students' performance on examinations?*

4. Results

As noted, students in the Fall 2015 cohort were given the option of attending lectures in-person, viewing videos of the lectures online, or using a combination of in-class and video lectures to prepare for their quizzes. Given the nature of the survey question asked, we grouped option b) "I prepared primarily using the video lectures" and option c) "I prepared using a combination of class lectures and video lectures" together. To test our hypothesis that the lecture delivery mode would impact students' performance on quizzes, we performed a one-way, between-groups ANOVA test to compare students' mean score, μ_n, on n quizzes:

$$H_o: \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$$

H_1: $\mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4 \neq \mu_5$

A significant effect was further analyzed using Scheffe's comparisons ($p < 0.05$). Although we failed to reject H_0 for the final two quizzes on LabVIEW, we did reject H_0 for the MATLAB quizzes: i.e., quizzes 1, 2, and 3), the mode of lecture delivery affected student grades. For quiz 1, $f(2,91) = 4.38$ with an effect size of 0.088: students who attended in-class lectures ($M = 18.6$, $n = 65$) performed better on quiz 1 than those who prepared with neither in-class or online lectures ($M = 16.8$, $n = 9$). For quiz 2, $f(2,74) = 3.80$ with an effect size of 0.093: students who attended in-class lectures ($M = 18.4$, $n = 53$) performed better on quiz 2 than those who prepared with online lectures ($M = 16.6$, $n = 19$). For quiz 3, $f(2,86) = 2.84$ with an effect size of 0.062: students who attended in-class lectures ($M = 18.3$, $n = 63$) performed better on quiz 3 than those who prepared with online lectures ($M = 16.9$, $n = 20$).

The first result is not surprising: for the first quiz in the course, students who didn't attend lectures or view online videos of the lectures performed poorly relative to those who did. However, the results for quizzes 2 and 3 were unexpected: students who primarily attended the in-class lectures (instead of using the online lectures), performed better than those who supplemented their learning with the online lectures.

In order to investigate this result further, these data were also analyzed using Pearson's correlation coefficient. The number of quizzes where students prepared using primarily in-class lectures and the average grades on quizzes were positively correlated, $r(97) = 0.27$, $p < 0.01$.

It is quite possible that these results say less about the relationship between mode of delivery and student success, and more about the group of students who choose to use the supplementary (online) lecture materials. More specifically, those who are struggling with the material may be more prone to revisit the lectures using the online videos. This link between the difficulty of the material and the use of the supplementary (online) lecture materials is supported by an increase in the use of the online videos as the term progressed (and the material became more difficult). As shown in Figure 1, the percentage of students who used the online videos to prepare for quizzes increased dramatically at the end of the term. Interestingly, in-class attendance also dropped: this is likely due to increasing demands on students' time from other courses as the term progressed.

5. Conclusions

The results did not show a clear improvement in student performance as a result of the supplementary online video lectures. However, it was very promising to see that students appeared to find these materials useful. In particular, there were a great variety of usage scenarios regarding in-class or online lectures. For example, when asked informally about the online video lectures, students commented that they helped significantly if they happened to be sick. Instead of having to ask friends for notes, they could simply watch the lecture online.

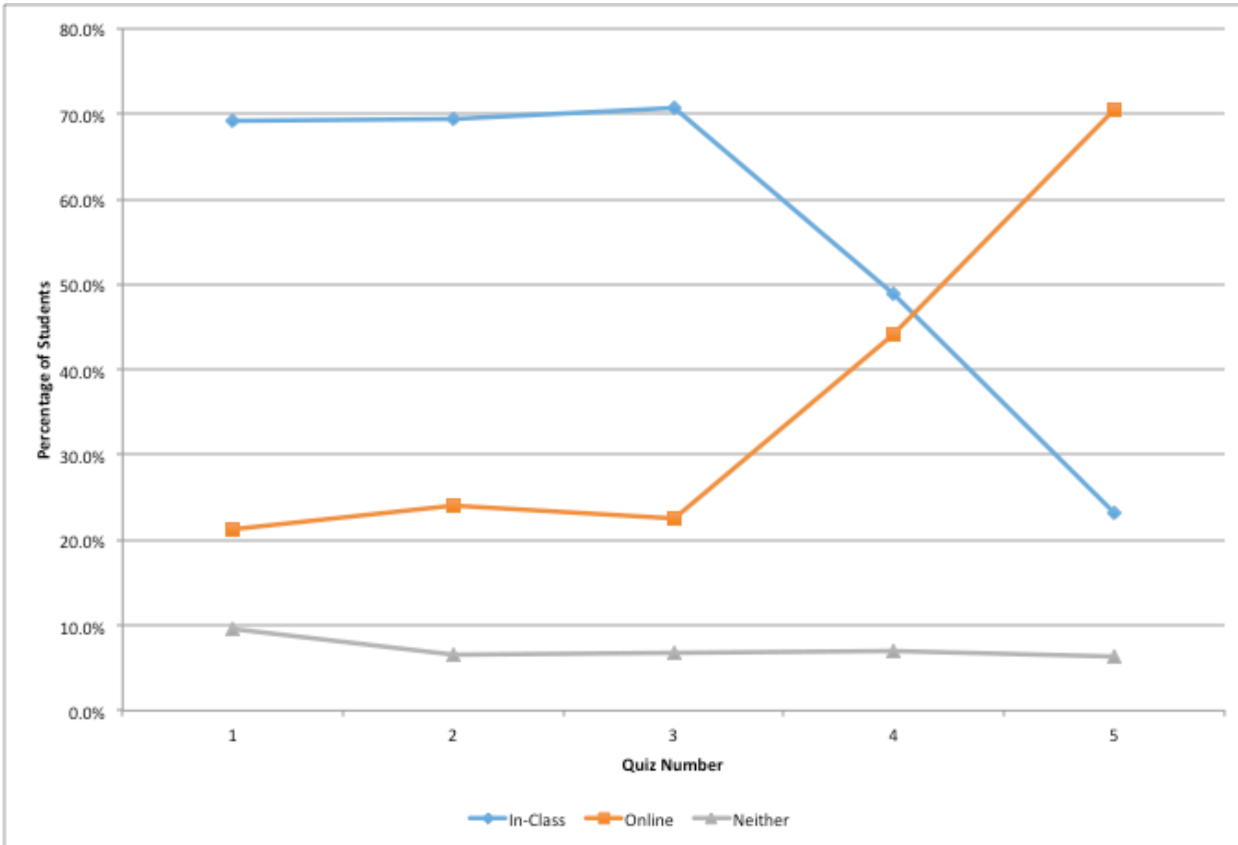

Figure 1. Student choice of lecture delivery mode

A key limitation of the study is the hybrid nature of the online videos: more specifically, since students could choose to attend in-class lectures, view online videos, or do both, it was difficult to explicitly link the mode of delivery directly to student performance. Although it appears that in-class delivery results in better performance, this result could be confounded by other factors related to the choice to use supplemental online lectures. For example, students who are struggling may be more likely to use online material, while students who are not having difficulties with the material may not see a need for supplemental lectures.

However, it is also possible that the supplemental lectures may detract from already limited student time for study. More specifically, rather than re-viewing lectures, there may be other activities that students could be performing outside of class that would be more beneficial (e.g., working on programming exercises, summarizing material, etc.). Recent studies on “flipped” delivery have pointed out that online lectures (especially in multiple courses) can require students to spend considerable time outside of classroom that could be spent on other (possibly more productive) activities[13].

In our future work in this area, we plan to explore the differences between in-class and online learning more directly by comparing student cohorts in traditional, in-class lectures to those with supplemental online resources as described in this paper. As well, we plan to investigate the effect that outside of class viewing has on student study time by surveying students who are participating in these courses.

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