A Case Study of Blended Learning for Mathematically-intensive Topics in a Large Engineering Class

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Extended Abstract

Introduction
We present a case study performed in an engineering undergraduate class in the field of data analysis. Like many engineering courses, the various topics covered involve the application of a relatively large body of mathematical/statistical theory to practical scenarios.

For students, being reasonably well-versed with both theory and its applications is well within the scope of the course’s specific learning objectives. Nevertheless, for the instructors, teaching the theoretical part has always been more challenging compared to any practical application, especially if it involves mathematics (Yuen, 2014). Students typically find theory to be boring, dry and uninspiring. The result is a poor uptake of the subject and agonisingly dull classroom sessions.

The objectives of this case study are to:
1. Improve students’ learning of critical aspects of data analysis, especially the most theoretical parts
2. Make the classroom sessions in this course more lively and engaging

Methods
Leveraging on available technology, we have implemented a blended learning environment (see for example, Garrison & Vaughan, 2011) to help achieve our course objectives. The weekly teaching activities are organised as follows, in chronological order:

- Video lectures: The teacher makes available a video lecture that covers the most theoretical and “dry” aspects of data analysis. The duration of each video is kept to within 30 minutes.

- **Online formative quiz**: An online self-assessment questionnaire is also made available to students. They are encouraged to try to answer the questions after watching the video lecture. The self-assessment questionnaire is not graded and intended as a measure for scaffolding the learning process. Multiple attempts are allowed.

- **The actual classroom session**: The theoretical content that underpins the data analysis application is not covered in the classroom session because it was covered in the video lecture. Instead, the session starts with the presentation of a specific application. The applications are chosen according to the research fields of staff in the department. Often, the analysis of data is performed on real published data. The fact that the theoretical background has already been covered in the video lecture allows students and the teacher to spend more classroom time on the details of implementation, as well as address its pitfalls and common mistakes.

- **Rewards system**: Throughout the classroom session, the teacher asks the class questions related to the theoretical content, and students who watched the video lecture should be able to answer them easily. The first student to answer the question is rewarded with a small prize, typically a small chocolate. This practice has the double objective of making classroom sessions more lively and encouraging students to watch the video lecture before coming to class.

- **Tutorial session**: Tutorial sessions are conducted with a smaller group of students in computer rooms. The tutorial assignment is made available several days prior to the session. During the session itself, the lecturer does not solve the whole problem. Instead, at pre-determined points, students are given 10 to 15 minutes to continue by trying a solution by themselves, before the lecturer eventually shows them the solution.

The weekly cycle described above was implemented for five consecutive weeks. The number of students in the class was 97.
Results and Conclusions

We have tried to gather as much data as possible to verify whether the objectives of the case study were achieved or not.

We conducted a specific survey to assess whether the objectives of the case study were achieved from the students’ perspective. Answers were gathered on a 5-point scale, from “Strongly Disagree” to “Strongly Agree” (Figure 1). Seventy students responded to the survey (73% of the class). Regarding the video lectures, students found them “useful” (92% indicating they agreed or strongly agreed) and an improvement compared to a traditional framework (91%). A smaller percentage of students (78%) found the online self-assessment quiz useful and 81% of them agreed or strongly agreed that the online self-assessment questions helped them identify topics that they had not fully understood. Finally, 88% of students found the rewards system enjoyable and 73% of them agree or strongly agreed that the rewards system helped them to stay focused in class.

Taken collectively, these results seem to indicate that, from a student perspective, the objectives of the case study were achieved. Nevertheless, we decided to investigate further in order to determine a more objective measure of achievement.

Thanks to the available instructional facilities, we were able to monitor how many students followed the recommendation of watching the video lectures before coming to class and how many of them took the online quiz before the actual classroom session. We found that only slightly more than half the class (56.2%) watched the video lectures at least once before coming to class. However, if we count the students who watched the video lecture at least once at any point in time, the percentage (average of all lectures) goes up to 79%, indicating that a sizable portion of students probably only watched the video in preparation for the final exam. Only 6 students did not watch any video lecture. On average, 72% of students attempted the self-assessment online quizzes. However, only a very low 3.7% took it before the classroom sessions as recommended. These numbers indicate that the survey results in Figure 1 paint a picture that is probably more optimistic than the reality.
We then tried to assess whether watching the video lectures translated in improved learning of certain topics (the first objective of this case study). Finding a measure for this is notoriously difficult. In the absence of suitable alternatives, we chose to look at the assessment of the course: three questions from the final examination were selected as representative of three topics. These topics were covered in three separate video lectures. For each, we looked at the performance of students who watched the corresponding video lecture versus the performance of those who did not. We found that in all three questions, the average score (as a percentage of the maximum achievable for that question) of the students who watched the corresponding video lecture was higher than the score of the students who didn’t (55% vs 38% for the first exam question, 69.3% vs 56.9% for the second and 54.3% vs 36.5% for the third). Nevertheless, if one chooses the commonly adopted 95% significance level, the difference was statistically significant in only 2 of the 3 questions (p-values were 0.09, 0.032 and 0.028 respectively).

In conclusion, we have presented the implementation of a blended learning environment that tries to leverage on available technology to improve students’ learning of topics with high mathematical and theoretical content and to make the classroom sessions more lively and engaging.

Endnote
1. The staff in the department do not teach this course. They simply pass the author some experimental raw data that they have already published.

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References