DESIGNING A MOOC ON THE LAPLACE TRANSFORM FOR BLENDED LEARNING

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Abstract. Here we describe a promising model where a small active-learning math class, co-taught as short lectures interspersed with group problem solving activities, was first turned into a MOOC, and then these MOOC materials were used as the basis for a flipped-classroom style blended learning experience. Here we describe elements of the design of digital content used for blended learning, and the faculty and student reflections.

1. Developing the online interactive text

1.1. **The original problem based, active learning class.** During a curriculum revision of the main differential equations course taught by the math department at MIT, a three week segment on the Laplace transform was removed. This content was then expanded into a short active learning course targeting a smaller population of advanced engineering students, teaching a signals and systems approach to system functions and the Laplace transform. This course was originally co-taught by two experienced faculty members through short mini lectures interspersed among group activities. This course had 8 students who met for 2 hours every day for two weeks during the Independent Activities Period (IAP) in January. This course ran in this format three times starting 2015.

1.2. **Creating the online interactive text.** An online interactive text was created to be used both as the source material for a MOOC on edX as well as for a new half-term residential course taught twice per year as a flipped classroom. The text is designed around worked examples [1], introducing new topics through solving one to three detailed, contextually relevant examples. It includes images or interactive web applets to help visualize content. Automatically graded concept questions assess understanding of new ideas; auto-graded computational practice problems, after the introduction of each new method. These problems fall into one of several problem types: multiple choice (choose one), choice response (choose all that apply), numerical entry, formula entry (mathematical formulas entered in ASCII format), sketch response (student sketches hand drawn into a web interface automatically graded with python), and applet interface (automatic grading of student settings of an interactive javascript applet). All problems have detailed solutions, offering immediate feedback to students after the all attempts are used, or a correct answer is entered. These problems offer immediate feedback to increase the efficiency of learning new concepts [2].

1.3. **Minimal use of video.** A small number videos are embedded within the text. These videos typically reinforce content provided in text an alternate source of material or provide an example problem worked out in detail. The online text is video minimal, relying on student learning through reading text rather than through live lecture capture video. The main caveat is four faculty voice-over lab demonstrations involving a tuned mass damper (TMD). The final activity of the course is to determine the system function of the TMD based on frequency response data using methods from the course. On campus, these are live demonstrations.

2. Comparison of MOOC and blended course

2.1. **The blended course.** The new blended course was taught as a half-semester Pass/Fail course, taught in the second half of the Fall 2017 and Spring 2018 semesters. This allowed students currently enrolled in Differential Equations to take the course. As opposed to advanced students, these blended courses ended up with exclusively first year students currently enrolled in differential equations. Many students dropped the course leading to a course size of only 5 students per term. An artifact of younger students and smaller class size was that students tended to work alone rather than collaboratively. One benefit of the online readings is that it was easy for the instructor (a postdoctoral instructor) to pick up the course and teach a flipped style class despite no experience teaching such a course before. His course ratings were high both terms he taught.

One online interactive lecture reading was assigned and due at the start of each face-to-face meeting. The reading presented several faded worked examples in different contexts, as well as conceptual checks, computational checks, and simple activities. Then open ended activities with self-reflection were presented in the face-to-face meetings. This element of self-reflection is essential to using worked examples effectively [1], and was essentially omitted from the MOOC — included only through the use of questions asking students to reflect on the problem solving process with a link to the discussion forum.

2.2. **Structure of the MOOC.** The MOOC was run over the summer of 2017 with 12 interactive lecture sequences, 4 problem sets which cumulatively tested students on the content learned in several lectures through applied math problems, and conceptual explorations. There was one exam at the end of the course, which was run over 9 weeks. Of the 5000 students who enrolled, 270 passed the course, which is more students than have taken the residential version combined. Students in the MOOC commented that there were not enough practice problems to cement their problem solving. We hypothesize this may be due to the omission of the self-reflection present in the collaborative face-to-face problem solving sessions used in the on-campus course.

3. Designing the MOOC for use in blended learning

Our goal in developing a MOOC around an interactive text tied to each lecture was to develop content for use in a residential course. The MOOC was created to crowd source the editing and debugging of our digital content before being used with a small class of between 4 and 8 on campus students. From the faculty perspective, a benefit of creating MOOC content to be used in a blended course is the development of an active learning class whose content and goals remain stable from year to year, instructor to instructor.

3.1. **Integrating activities into the online text.** For the MOOC and blended course, we wanted to include many of the activities done in small groups in the original course directly into the interactive text. These activities were multistep problems that used many ideas presented within the online lecture and/or previous online lectures. The context or problem would be new to the student, though modeled or partially scaffolded in other worked examples set in different contexts. The main issue in translating these in class activities into online activities was that many open ended problems and examples had to be given additional hypotheses, which created "closed" examples – examples that had no ambiguity, lending themselves to a single answer, easily automatically graded within the edX platform. Unfortunately, the self assessment and student explanations that happen in class were not easily moved into the design of these activities [1].

These activities were structured to give "semi-delayed" feedback. While the activity itself would require an involved computation involving many steps, each activity would have only one or two answer boxes, requiring a number or a formula entry. Students must work through the entire process before receiving any feedback, and then must self assess to determine at which step their process failed, the type of feedback preferred by more advanced students [2]. MOOC students reported needing more support and feedback, while residential students were able to finish on their own, or discuss with classmates to determine the correct answer without much struggle.

3.2. **Building problem sets through backwards design.** We employed a backwards design model [3] — first looking at the problems we ultimately wanted students to do on the homework, then we checked to make sure that the online text problems and activities were aligned with these goals. The content was revised until the alignment of intended outcomes was met. Four online problem sets were created for the online MOOC students. Notably, we removed some problems given to residential students that required proofs or other techniques, which did not lend themselves naturally to automatic grading through the edX platform. In this way, we allowed the intended outcomes of the MOOC to be a subset of the intended learning outcomes for our residential students. Residential students worked on their problems sets in their face-to-face sessions and turned in a paper to be graded in detail at the end of each week.

4. Conclusions

Teaching a flipped classroom style class via an online interactive text designed around worked examples and coupled with collaborative groupwork activities seems promising. However, we need to experiment with how and when to run the course to get a more diverse audience and support our students better in forming groups to collaborate and reflect on the problem solving process. Next year we will run the course again over IAP, but as a flipped classroom experience.

References

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