

Using edX for blended learning in physics at UBC

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Abstract. This article describes the development of a blended introductory physics course that combines active learning in class with online resources hosted by an edX edge SPOC. We discuss the challenges we have encountered and the opportunities we believe exist in this format.

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1 Introduction and Description of the Blended Course

Physics 100 is an introductory algebra-based physics course at our institution. It is taken by approximately 800 students annually that need the course as a prerequisite. The course has four sections: three sections are offered in the fall term as a blended face-to-face course on campus while the fourth section is scheduled in the summer as a distance education course. In the following, we will refer to these offerings simply as "campus course" and "distance course", respectively. The same resources, hosted on an edX edge website as a SPOC, are used for both, the distance course and also the campus course. The website is free of charge for all registered students and integrates all course materials, including an online textbook (OpenStax College Physics), reading assignments, quizzes and homework problems, a test bank for bi-weekly tests, as well as materials that support the online lab.

The campus course is mainly taken by incoming first-year students. These students are certainly benefitting from the guidance of an instructor and the social interactions in the classroom. In the context of the blended campus course, we think of the online resources as support for self-directed learning outside of the classroom. The distance education course is mostly taken by upper-year students that are more likely to have acquired sufficient study skills to learn without instructor support. As the edX website is the only resource for the distance course, it has to make sense on its own, independent of any face-to-face instruction. We are still exploring how instructors in the blended course best use the edX page to guide their students in interacting with the online resources. The website is still under development and is certainly not perfect. Below we describe the challenges we have encountered so far, and the opportunities we believe exist in using the edX SPOC in our blended course.

The blended format of the campus course is a consequence of the development of the distance course that started in 2013. A requirement for the distance course was that the same topics are discussed, that it contains a laboratory part, and that it is at the same level of difficulty as the campus course. Moreover, it should engage students in active learning tasks, similar to the campus course that was already in a flipped format and featured pre-class reading, small group work on worksheets, and peer instruction with clicker questions. Ideally all active learning elements would be present in the distance course as well. Several things became apparent during the development of the distance course:

1. A weekly organization helps students stay on track. This is in part because our students are mostly local students that take face-to-face courses at the same time.
2. The course management platform (Blackboard) that was initially used has a number of limitations and is not well-suited to deliver a distance course. For example, integrating flowing text with embedded multiple-choice questions or videos takes a lot of manual coding and makes even small adjustments and corrections cumbersome. Moreover, resources such as an online homework system and the Piazza discussion forum were hosted externally with links and separate accounts. This made it hard for students to keep track of due dates. By contrast, a MOOCs platform such as edX edge offers a high level of integration and flexibility.
3. The course has many parts that do not necessarily appear coherent to the students. Some of the subdivisions that make sense in a face-to-face course, such as lecture activities, pre-class reading, and tutorial activities do not make sense online. We believe that a SPOC or MOOC can help making connections between course elements, for example by grouping concepts, relevant example videos, and homework under one header.
4. Effective textbook reading is difficult for students. Targeted reading assignments with instructions and quizzes seem to work well [1], but require three separate resources: the textbook, reading instructions and reading quizzes. In a MOOC/SPOC these can be designed as integrated reading assignments with quiz questions embedded directly into selected and customized text, which helps students with this difficult task.
5. Hands-on labs can be online and basic experimental tasks can be done at home. Support for experiments and data analysis with spreadsheets can be accomplished with videos and online discussions. This made the development of an online lab possible for our physics course.
6. Much learning can be done outside of class with online support. Disciplined, self-directed learners thrive in such an environment. Others need social interactions to stay motivated and need more support than the online environment is able to offer. Students thus need to have some experience with university-level courses before they can judge whether or not a distance course is suitable for them. Offering the distance course in summer is prudent because students will then have completed at least one year of university.
7. Designing and interacting with an online course helps instructors see the course from the perspective of the students. Everything needs to make sense

on its own without additional explanations. It provides the designer/instructor with a unique holistic view of his/her own work. This in turn challenges us to think about the resources that students are typically offered in a face-to-face course. Are lecture slides useful for learning? How are students interacting with posted solutions? Do students make connections between reading assignments, lecture slides and homework? In our experience, many first-year students study from these resources in a fairly passive mode, i.e. just reading and highlighting instead of re-testing themselves on the material (see for example the discussion by Roediger and Karpicke [2]). We believe that a SPOC can support students' studying and learning at home much better by engaging them in active learning tasks.

2 A few results

The blended campus course was running for the first time in the fall term of 2016. The course content and in-class activities remained the same as in previous years, but the course textbook and the online homework changed. An electronic version of College Physics by OpenStax was imported into the edX website and customized into re-formatted weekly reading assignments. The end-of-chapter textbook questions as well as previous exam questions were coded to create a question database that is used for weekly online homework and as a test bank for bi-weekly testing. Following the course, we administered a student survey and ran focus groups. We also looked at exam results and data from the CLASS attitude survey.

The final exam results in 2016 were very similar to those in previous years. The exams questions were designed by the same instructors using overall a similar format, so results are generally comparable. It was important for the instructors that exam results did not suffer since we switched from a well-established, widely-adopted commercial text and online homework system to a free custom solution.

Course attendance (70% on average) also did not change from previous years although students could learn the course content from the SPOC. Numerous active learning tasks in class and minor marks for answering clicker questions help keeping the attendance up.

The CLASS attitude survey did not show any significant changes in the overall results compared to previous years, but there was a slightly negative change in the problem-solving category. Several factors may have contributed to this: doing homework was not rewarded with marks in 2016, changes in the structure of the tutorial/recitation sessions, and perhaps insufficient feedback on the electronic homework (just correct/incorrect). We are currently creating animated worked examples, which will be embedded into the homework. These examples demonstrate expert problem-solving skills and may help our students become better learners (Gladding et al. [3]). In addition, we will reward doing homework with marks again and provide more customized guidance in our recitation/tutorial session by bringing in more teaching assistants.

Feedback on the edX edge resource was overall positive. Not surprisingly, students appreciated the fact that all resources were available at no cost to them. They also commented quite positively on the appearance and organization of the edX website, and in particular on the customization of the reading assignments (Hendricks, Reinsberg, and Rieger [4]).

We ran focus groups and asked students about their experience with the online labs. The participants said that the labs were easy to do, but not very motivating. They also reported that it was occasionally difficult to find materials in their student dorms and mentioned that students sometimes cheat and fake their data, usually because of poor time management. The labs require students to design their own experiments and use simple materials that they either have at home or that can be purchased at fairly low cost. Accordingly, some planning and organization is required to complete the labs and leaving the experiments until the deadline is thus very counterproductive. Generally, students preferred labs on campus to the online labs, mainly for these organizational reasons. On the other hand, overall learning in the online labs is the same as in previous years when students did most experiments in a teaching lab on campus.

3 Discussion and Future Work

We have developed a self-contained SPOC on edX edge that is used for blended face-to-face instruction, as well as for distance learning. In the context of our blended face-to-face course we see this resource as a way to support students' learning outside of the classroom.

The website allows our students to do all learning at home. Nevertheless students still attend lectures regularly because they appreciate the benefits of live lectures and tutorials, mainly the social interactions with peers and instructors, and the work they do in small groups on worksheets or during clicker questions. Age is probably an important factor here: most of our students are 18 to 20 years old and still need some guidance as well as the added motivation a classroom environment provides. In our view, the blended format has a lot of potential and offers the best of both worlds: it combines learning with peers in a classroom with a customized study tool that supports their learning at home.

Yet, we currently have no evidence for improved learning with the new resource. This is not surprising given that we have used the new resources in the blended course only once so far. It will likely take some adjustments to the activities in class and further improvements of the SPOC to see improved learning, such as providing more detailed feedback on the homework. The SPOC is currently undergoing further developments and interactive videos are added to help students acquire essential problem-solving skills and increase motivation. In addition, instructors need to think about how they could make better use of the resource. For example, worked examples and practice problems can be very efficiently delivered by the SPOC. This frees up time in class to talk about learning strategies and how to best interact with such examples. Future offerings of the

course and more research will help us gain more insights into the interaction between in-class activities and online elements.

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