

Bioelectricity-AQA, one of the first MOOC courses in Engineering.

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Abstract— Bioelectricity-AQA was one of the first massively open online courses in engineering, having been given the first time via Coursera starting in September, 2012. This report provides some detail on its background, presentation, enrollment, and lessons learned.

I. INTRODUCTION

In the Summer of 2013, Peter Lange, the Provost at Duke, decided the university would participate in “massively open online courses” (MOOCs), then an innovative new idea. Working through Duke’s Center for Instructional Technology, he recruited faculty members to teach the initial group of 10 courses originating from Duke. The first of the Duke courses to be given was *Bioelectricity-A Quantitative Approach*, which at Duke is an engineering course. During the development and offering of the course the CIT and Provost’s office tracked progress. Thereafter, a university report by independent professional evaluators Yvonne Belanger and Jessica Thornton summarized their key findings as follows[1]:

“Over 600 hours of effort were required to build and deliver the course, including more than 420 hours of effort by the instructor.

- The course launched on schedule and was successfully completed by hundreds of students. Many hundreds more continued to participate in other ways. The number of students actively participating plateaued at around 1000 per week.
- Over 12,000 students enrolled, representing more than 100 countries. Approximately 8,000 of these students logged in during the first week.
- At the time of enrollment, one-third of enrolled students held less than a four year degree, one-third held a Bachelors or equivalent, and one-third held an advanced degree.
- 25% of students who took both Week 1 quizzes successfully completed the course, including 313 students from at least 37 countries. Course completers typically held a Bachelor’s degree or higher; however, at least 10 pre-college

students were among those who successfully completed this challenging upper level undergraduate course.

- Students who did not complete all requirements cited a lack of time, insufficient math background or having intended to only view the lectures from the outset. Regardless of completion status, many students were primarily seeking enjoyment or educational enrichment.
- Most students reported a positive learning experience and rated the course highly, including ones who did not complete all requirements
- The Coursera platform met the needs of the course in spite of being continuously under development while the course was live. Technical issues reported by students and instructor were generally minor, of short duration, or quickly resolved.”

II. SAMPLE SLIDES



How is electricity in living tissue different from the “ordinary” electricity of batteries, wires, radios and computers?



What happens when you throw a standard battery into the ocean?



Figure 1: “Ordinary” electricity vs. Bioelectricity



What happens when you throw a fish in the ocean?



Fish does fine.



This ray does too .

Figure 2: A fish, and a ray

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The presentation format was that of a sequence of power-point slides, with the instructor talking about each one at the time it was shown. Figures 1 and 2 give 2 examples.

III. SEQUENCE OF TOPICS

The course followed the same outline as used in the Duke course on Bioelectricity for residential students, a course often taken by students in their 3rd undergraduate year, and similar to the sequence of topics in the Bioelectricity textbook by Plonsey and Barr [2]. The course begins with topics such as “What is Bioelectricity?” and then proceeds, quantitatively, though topics such as resting potentials, membrane models, propagation, extracellular wave forms, and stimulation.

The course was not simplified to make it into a course for a general adult audience. Rather, the goal was to present the real Duke course using another means of delivery.

IV. COURSE PREPARATION

After the course was first offered, the instructor was quoted as saying: “Creating the course was a big enterprise, with much more to it than I originally imagined. It was done piece by piece, no one that difficult, but there are a lot of pieces and they should fit together. Usually they did so.”[1].

Here is how it became an enterprise with many individual pieces. There were 8 weeks of video presentations. Each week of video had about 20 segments, each one nominally 10 minutes in duration. In each of the 20 segments, there were five to ten power-point slides. For each of the segments, there were accompanying questions, both qualitative and quantitative.

These items were not particularly different in their style or creation from those used in classes taught each year in many universities. The difference here was that the goal was to create them all in advance of the course’s beginning, to have them organized on servers at Duke and at Coursera, and to have them become available to students at fixed dates and times. In the normal course of events, individual items were improved and replaced. There was a lot to index and manage, especially as selective revisions were made. With good staff support, as was present here, doing so was not a significant issue. Without good staff support, it would quickly have become impossible.

V. PLATFORM FOR DELIVERY

The administrative arrangements between Duke University and Coursera, a corporation in California, were established (on the Duke side) by the central administration, primarily

the Provost and his staff. Coursera operates a system of computer servers that gives students access to the courses it provides.

A simplified view of how the platform works is that, on the one hand, it enrolls students from around the world, handles their registration, and deals with technical issues of data communication with them as the need arises. On the other hand, Coursera deals with individual universities, and through them the individual faculty members offering courses through Coursera.

Speaking loosely, people describe the arrangement as “the universities own the courses and Coursera owns the students.” It is a fundamentally different relationship from that of a traditional Duke student, who deals directly with the university.

Technically the Coursera platform offered the opportunity for the course to use instructionally attractive features not normally present in residential courses. That is, the platform did a lot more than simply play videos on a particular schedule. For example:

A. Videos had sub-titles. The sub-titles could be in English or other languages. Considerable student-initiated translation took place.

B. Videos paused every few minutes for each student to answer a question before proceeding. Such questions were best selected as relatively simple ones, used to ensure that the student was tracking the main idea being presented. Students liked this feature, as did the instructor. (Inserting the questions did require another pass through each video, during course preparation.)

C. Mastery questions were more easily created. A mastery question is one that changes form or content from one time it is asked to the next. The consequence is that the same student can take a quiz, miss questions, and take the same quiz again without seeing the same questions again. In a careful study performed by Daphne Koller and colleagues of Coursera, this method of bringing students forward was shown to be superior to the traditional “test-once” style normally used.

D. Peer grading works with a controlled scoring rubric. Some questions are best answered in an essay format, e.g. identify a bioelectric signal from a tissue not discussed in the course, and describe how it is used. Peer grading means that the question is read by other students using an instructor-defined grading rubric. With large numbers of students, it works, not every time, but enough times to be effective, and with scoring close to that of the instructor.

E. Automated scoring. Most exams were scored in an automated fashion. Question types include those normally expected, such a multiple choice, but also those that might

not be, such as free-form computer code, mathematical equations, and many forms of numerical answers. Automated scoring allows multiple question forms and many numerical variations.

F. Good indexing. Because short segments link together to form the course, good indexing of segments becomes possible. The ability to go back to particular segments and replay them was frequently cited as highly attractive by students.

As a whole, the Coursera platform provides a more powerful mode of course presentation than normally is available in traditional courses.

VI. STUDENT INTERACTIONS

It is sometimes imagined that there is little person-to-person interaction in a MOOC course. Experience shows that the opposite often is the case. Students repeatedly see and perhaps identify with the instructor in a strong and personal manner, perhaps similar to response to people in movies or on television.

On Coursera, students talked to each other via “the forum,” a kind of chat room that is most often organized by technical topic, though it contains many more personal chats under the category “Who am I?” The diversity of students from around the world brings an element of sophistication and excitement that may not be present in a single residential class. Students also used text messages, email, social media, and where practical organized meeting groups.

VII. WHO ENROLLED

About 12,000 students enrolled in the course each time it was given (September 2012 and January 2013). Of these, about 2000 were active throughout the 9 weeks of the course, and about 400 earned a certificate. For comparison, about 50 Duke engineering students per year complete the residential course.

Students enrolled from about 100 countries around the world. About two-thirds of the students who enrolled had a bachelor’s degree at the time of enrollment, though some students enrolled who were still in high school. Students enrolled primarily simply out of interest in the topic, though a significant number enrolled in relation to their jobs or possible future jobs. Students who began the course but did not complete it typically cited a lack of time, week after week, rather than a lack of interest.

VIII. LESSONS LEARNED

Bioelectricity is often viewed as a highly specialized advanced subject. That view notwithstanding, there are

many people around the world who enrolled and then devoted a substantial amount of time to the course. This is a subject that has been kept too much “in the box.”

The traditional course semester is too long for a MOOC course. It would be better if the MOOC course was presented in a series of shorter course, perhaps 3 to 6 weeks each.

For committed students, the level of quality of a MOOC course can be similar to that of a traditional residential course, as judged by the successful completion of questions of comparable difficulty asked at the end of the course. This aspect of the course led external evaluators to recommend ACE college credit as an upper level undergraduate course. (Taking into account the shorter duration and thus more limited topic coverage, they recommended 2 course hours credit.)

Issues of security and plagiarism are overblown. There are mechanisms existing now that provide several levels of security, if desired. These include multiple variations and versions of questions, making it difficult or impossible to have a fixed “answer key,” analysis of the timing and pattern of keystrokes to verify that the same person is always at the keyboard, and video proctoring of an exam room to determine the student’s surroundings. Plagiarism seems to be instantly recognized and quickly repudiated by other students in a peer-grading context. At the same time, as instructor one learns to keep in mind differing outlooks toward copying present in the USA [4] and around the world.

A written transcript of the instructor’s presentation, done by a commercial service, was heavily used by students. The original transcript was in English, and it was rapidly translated to other languages by volunteers. That allowed the course to proceed in multiple languages simultaneously.

There is an intensity present when dealing with students who want to know *right now* that is not present with students who are diligent but learning information toward some more distant goal.

IX. RESPONSE OF STUDENTS

The expectations and then the response of students to the course was evaluated by surveys available to all course participants, as well as by formal as well as informal analysis of comments in the course forum.

Student response to the course was strongly positive overall. The instructor received wonderful thanks through the course forum, and through other email. Student performance by objective measures was varied, with the best students being equal to and perhaps superior to those students normally a part of a Duke residential class. In the aggregate, most students reported a positive learning experience and were

delighted they had taken the course, *even if they did not complete the course.*

The video and computer based platform did not seem to be an issue or a concern for the large majority of students, with two exceptions. One group for whom it proved difficult were those students living in areas of the world where computer transmission speed and reliability remain low and limited. This group had to download videos to completion, save them, and then replay. They found it much harder to do the online quiz work, for which a similar mechanism was not available.

Another group of students who were enrolled were simultaneously residential Duke students. Some of these students felt that the Coursera course presentation was not as good because they were entitled to have the instructor appear in person; others however felt the opposite. Duke students also were conflicted about their own relative importance when co-mingled with the much larger group of Coursera students.

X. UNIVERSITY MOTIVES

Officials at Duke described the university's motivations for being involved with MOOC courses as

- Promoting teaching & learning experimentation; innovation
- Global outreach; service to society
- Enhance Duke's reputation

XI. NEGATIVES

There are two significant negatives to MOOC courses that are not yet overcome.

One is the evolving and unstable nature of the financial model underlying the courses. The opportunity for students to enroll free of charge is wonderful, from the student's perspective. At the same time, production of the courses is costly. Various avenues have been proposed but remain unproven.

A more fundamental educational question concerns the supervision of students. There is no doubt that the MOOC model is powerful and effective for students who are highly self-motivated. It is of doubtful effectiveness for a student who needs a degree of supervision in relation to the balance of academic and non-academic time allocation. Again various avenues have been proposed, mostly involving use of instructor's aides or teaching assistants.

XII. COURSE CREDIT

Students completing the course and receiving a sufficiently high score on weekly quiz exercises and the final exam received a certificate of that accomplishment. Two levels of certificates were given, the first for answering qualitative questions only, and the higher level for answering both qualitative and quantitative questions. Students had an intense interest in qualifying for a certificate.

In the 2nd offering of the course, ACE credit was available for students who took a special final exam. (ACE credit allows transfer credit at many institutions.) This final exam had a large number of both quantitative and qualitative questions, and was proctored exam.

XIII. CONCLUSION

Developing and teaching this course was intense. It also was an intensely fascinating experience as judged by students, faculty and observers [5]. There are many people around the world who would like to know more about engineering than they do, and for whom enrollment in engineering programs is not possible. For others, the MOOC courses serve as an introduction that may be followed by later enrollment in a formal program. The MOOC format offers a way to reach this large group of interested and talented students, of whatever age they may be.

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