Bioelectricity: A Quantitative Approach

Duke University's First MOOC

February 5, 2013

Summary

After only three months for planning and development, Duke University and Dr. Roger Barr successfully delivered a challenging open online course via Coursera to thousands of students around the world. Lessons learned from this experience have contributed to the strategic goals of Duke's Online Initiatives.

- 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 the students and instructor were generally minor, of short duration and/or quickly resolved.
- Patience, flexibility and resilience on the part of instructor, Coursera students, CIT staff, and Duke University Office of Information Technology media services staff were key elements in the success of this course.

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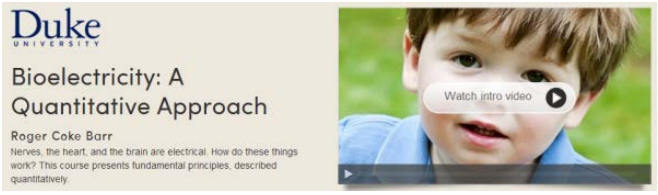
Project background and acknowledgements

In 2012, Duke University began an Online Education Initiative to experiment with emerging models and technologies for online education. In July 2012, Duke University announced a partnership with Coursera[1] which aimed to offer a number of Massive Open Online Courses (MOOCs) over the following year. A small group of faculty willing and able to develop courses to be delivered via this new platform in the 2012-2013 academic year was identified in May-June 2012, and the initial announcement included eight planned courses, the first of which was scheduled to launch in September 2012.

Duke's first MOOC, *Bioelectricity: A Quantitative Approach* launched on September 24, 2012. Open to enrollment for anyone around the world, this free eight week course of study was developed and taught by Roger C. Barr, Anderson-Rupp Professor of Biomedical Engineering.



This report summarizes the development and delivery of this course, describes the students who enrolled, the student learning outcomes measured, and the experiences of those students, the instructor, and the staff who supported the course's development and delivery. Finally, this report offers lessons learned and broader implications for Duke's online initiatives (http://onlinecourses.duke.edu/), which aim to:

- Promote teaching & learning experimentation, innovation
- Support strategic goals of global outreach, knowledge in service to society
- Enhance Duke's reputation

Acknowledgements

This report was made possible by contributions, feedback and support from:

Dr. Roger Barr (Instructor, *Bioelectricity: A Quantitative Approach*)
Zachary Abzug (TA, *Bioelectricity: A Quantitative Approach*)
Zahra Asgari, (TA, *Bioelectricity: A Quantitative Approach*)
Duke's Center for Instructional Technology
Duke Digital Media Services
Dr. Peter Lange, Provost, Duke University
Dr. Lynne O'Brien, Director, Duke Center for Instructional Technology
Dr. Keith Whitfield, Vice Provost for Academic Affairs
Members of the Duke Faculty Committee on Online Assessment and Academic Committee on Online Education

[1] Coursera (coursera.org) was founded in January 2012 by two faculty from Stanford University. As of December 2012, 33 universities had partnered with Coursera.

Announcing and building the course

This course was first announced in a press release by Coursera in July 2012 publicizing its partnership with Duke and 15 other institutions. Students began registering immediately; by the week prior to launch over 10,000 students had "enrolled" via the course introduction page on the Coursera web site.

Dr. Roger Barr has taught courses in bioelectricity at both the undergraduate and graduate levels at Duke University for over 20 years. In a typical semester at Duke, a relatively small group of 20-30 students enroll in the corresponding course at Duke. The eight-week Coursera version developed by Professor Barr was loosely based in structure and scope on *Bioelectricity, A Quantitative Approach* by Robert Ploney and Roger Barr, currently in its 3rd edition (Springer Publishing). Intended as a self-contained course organized around themes, *Bioelectricity* was aimed at advanced undergraduates or early graduate students in science and engineering, but the course was open to any student regardless of background. Students were not required to purchase or have access to the textbook, although it was suggested as a reference text. The content in the Coursera version of *Bioelectricity* differed from the textbook in terms of mathematical depth and the number of topics included, with the text being more comprehensive and detailed than the Coursera course (see Appendix B: Syllabus from *Bioelectricity, A Quantitative Approach*, Fall 2012). As taught on Duke's campus, *Bioelectricity* also includes laboratory measurements.

The time and resources required to develop and deliver this type of course was unknown at the outset. CIT surveyed instructors and staff involved in course development and delivery on a weekly basis before and during the course to assess the amount and type effort involved in creating and delivering a MOOC. In total, more than 620 hours of effort were recorded for preparation and course delivery - 420 hours by the instructor and at least 200 hours by the TA, instructional support, technical support and assessment staff from CIT and OIT.[2]

The anatomy of Bioelectricity

8 weeks long

11.3 hours of finished video

97 published video segments

22 GB of data

1052 files

18 graded exercises, including a peer-graded writing assignment and final exam

Nearly 22 gigabytes of data files were created in connection with the course, including over 11 hours of video for the 8 week course. More than 1000 files were created including 97 "final" videos published to the Coursera course site (12 videos per week, plus a promotional video for the launch page).

Dr. Barr spent approximately half his total effort prior to launch in course planning, development and designing quizzes and assessments. Although the course was based on the reference textbook and previous face to face versions, including an existing question library used to build the exercises and exam, the instructor still had to develop a customized course plan for the online version. He produced

[2] The first survey was distributed on August 13, 2012 for Dr. Barr and the following week to staff. Given missing data for various reasons, these are low conservative estimates, particularly of staff time.

87 video segments using a video kit which include a Macbook Pro, Screenflow software, and assorted audio/video accessories, and shot the remaining ten videos in a studio with the assistance of Chris Lorch of the CIT). Staff provided training to the instructor on how to use the video kit, reviewed initial videos and provided production advice. Most videos were created by the instructor with minimal production assistance; as a result, the video production support needs were relatively low. In addition to the ten videos shot in a studio setting, DMS provided additional editing and post-production services for other videos shot by the instructor, but the overall amount of post-production was small.[3] In total, 12 hours shooting and editing plus 25 hours of video editing work were devoted to the course by the DMS staff.

Launching the course

A week prior to the course site being opened by Coursera, a 'Getting to know you' questionnaire was distributed by email to approximately 11,000 enrolled students (3,576 responded).[4] Pre-course surveys focused on demographic information, student motivations for taking the course, and expectations of how the course would progress. Summary data from this questionnaire was used to facilitate the instructor's understanding of the students' background, motivations and goals. Enrolled students resided in over 100 countries, with only 1/3 currently residing in the United States. Approximately 2/3 of students reported holding at least a Bachelor's degree; only 1/3 reported having specific coursework or expertise in the subject. A majority reported being over 25. (See *Figures 1a-c, Enrolled Student Demographics*).

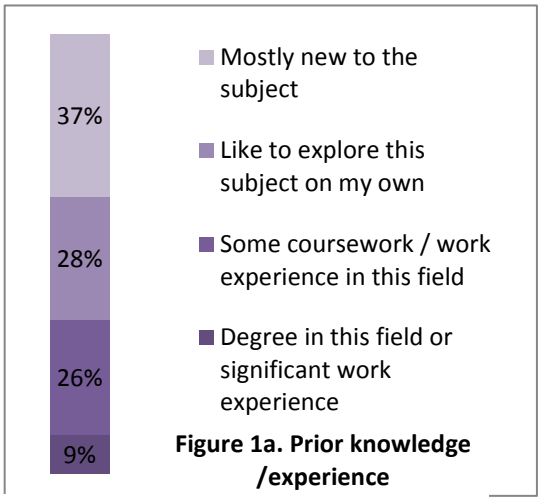


Figure 1a. Prior knowledge /experience

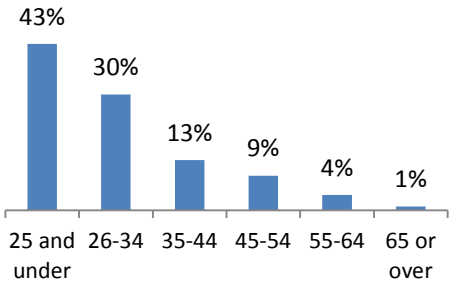


Figure 1b. Age

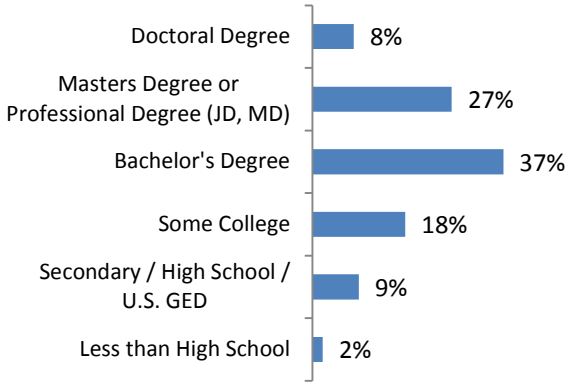


Figure 1c. Highest prior degree

[3] The instructor began producing videos before a final PowerPoint template with Duke branding was available.
[4] It is unclear how to compute a meaningful response rate. These students represent approximately 29% of enrolled students, but many enrolled students did not log on after the course was launched. This number also represents 46% of students who watched at least one video.

The course launched on September 24, 2012. The content published in the first week included 12 video segments and 2 quizzes. Within a day, approximately 42% of registered students had logged into the course site, and of those who logged in, 2/3 had watched at least one course video in that first day.[5] Students also immediately began introducing themselves via the forums (see *Sample student introductions*, right).

Sample Bioelectricity student introductions

"I'm an engineer, focusing now on robotics…."
"I'm a science fiction writer…"
"I am a retired chemical engineer…"
"I am machine learning expert based in Hyderabad"
"I am a final year medical student from Brazil…"
"I am an English Literature student but interested in science…"
"I'm a stay at home mother…"
"I'm a freelance technical writer…"
"I'm a registered nurse…"

Delivering the course

The general pattern established in the first week was repeated throughout the duration of the course with the exception of Week 7 when one quiz was replaced with a peer-graded writing exercise. A final exam was also included in Week 8.The content each week consisted of approximately two hours of videos divided into 12 segments. Dr. Barr also attached a PDF file containing the un-annotated slide images used in all lectures during the week. To assess students' understanding and ability to apply the concepts, two graded quizzes were included each week, known as the "A" quiz series (qualitative multiple choice questions) and the "B" quiz series (quantitative questions requiring numeric solutions). Although the number of questions per week varied, student scores were scaled from 0 to 10, in proportion to the number of correct answers, so each week's scores were weighted equally throughout the course. Students were granted repeated attempts at all exercises, and their grades reflected the maximum score across all attempts. Quizzes also used randomization, so although students were allowed repeat attempts, question values and answer options varied in each attempt. To reduce the incentive to guess without thinking, the instructor enforced a two hour delay between quiz attempts.

Dr. Barr and his TA Zachary Abzug monitored the course site daily. During the course, they corresponded with students via the discussion board, investigated and responded to reports of errors in the content or exercises, posted general notes and updates to the course participants, reviewed student activity data, and attended meetings related to the course. In addition to routine engagement in the discussion forum as well as weekly updates, announcements and reflections posted online and sent by email, they maintained a "Hints and Kinks" page with corrections, errata and tips to help students with difficult exercises. Students also occasionally reported suspected errors in the scoring of quizzes. The instructor and TA would investigate these issues and if appropriate, would modify the quiz answer key and regrade student submissions as needed.

Half of the time reported by the instructor was spent while the course was active. About one quarter of instructor's overall time was spent before and during the course on various aspects of collaborative planning with CIT, course assistants or Coursera personnel – for example, discussing and selecting

[5] See *Bioelectricity, Day One* http://cit.duke.edu/blog/2012/09/bioelectricity-day-one/

options (within the capabilities of the Coursera platform) for how to implement the course activities. A majority of the hours spent by staff were dedicated to monitoring discussion forums, building quizzes and assessments, consulting on course design issues and supporting monitoring and assessment of the course.

The discussion forum remained active and typically reflected a high caliber of academic rigor and significant student effort. Although the instructor and TA were active participants, students also frequently responded to one another's questions. In addition to English, discussion threads were carried out in many languages including Russian, Greek, Portuguese and Romanian. Students also built a Course Wiki with lecture notes, hints of their own for the exercises and links to supplementary content from various web sites. They also contributed translations of video transcripts in several languages including Spanish, Chinese and Indonesian.

Course activities and student interactions extended beyond the Coursera web site. Over 80 students joined a Facebook study group and others expressed the intention of connecting via other forums (e.g. exchanging Google+ and Skype contact information via the discussion board).

Wrapping up the course

After the end of the course, the gradebook scores were weighted and the instructor's grading policy was applied to determine which students had successfully completed all requirements. A certificate of distinction[6] was awarded to 261 students who achieved an average of 70% or more on the total of the A quizzes and exams and B quizzes and exams. Additionally, a basic certificate was awarded to 52 students who scored at least 70% on the A series of qualitative questions but did not meet the distinction level criteria. Students were notified by email that they could see and print their Certificate online via Coursera. Also, all enrolled students were invited to submit feedback about their course experience via an online survey link.

Assessment of the course and outcomes

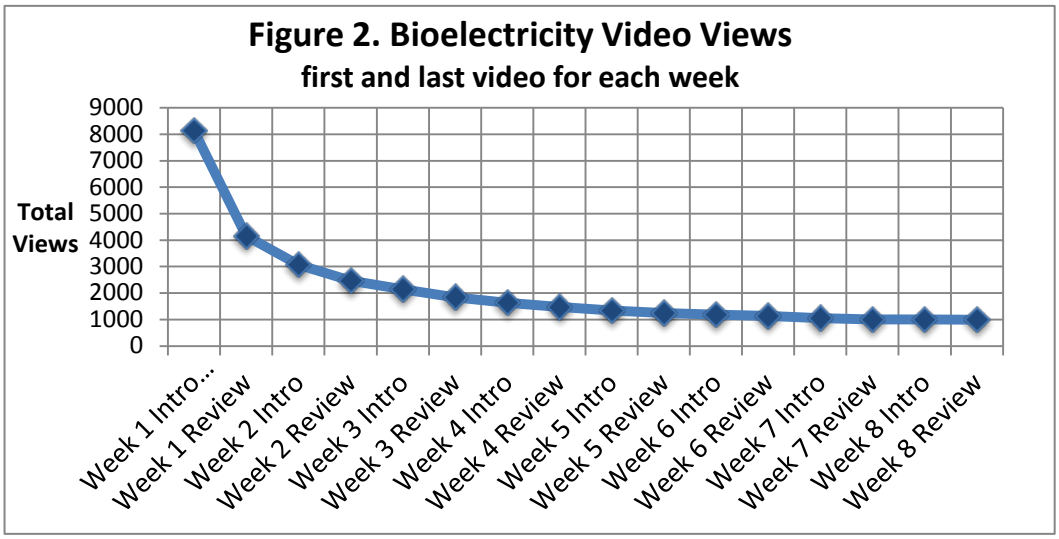
Data were gathered and analyzed before, during and after the completion of the course. Pre- and post-course survey responses were supplemented with analysis of the online discussion forums. Activity statistics available via Coursera included student activity metrics as well as student performance on exercises. Time tracking, administrative records and reflections from staff and the instructor also contributed to the assessment of the course. Graduate students in Dr. Barr's campus course, who had viewed the online lectures and completed the quizzes in Coursera, shared their thoughts in a focus group which contributed to our understanding of the feedback received by the online students.

Student activity and outcomes

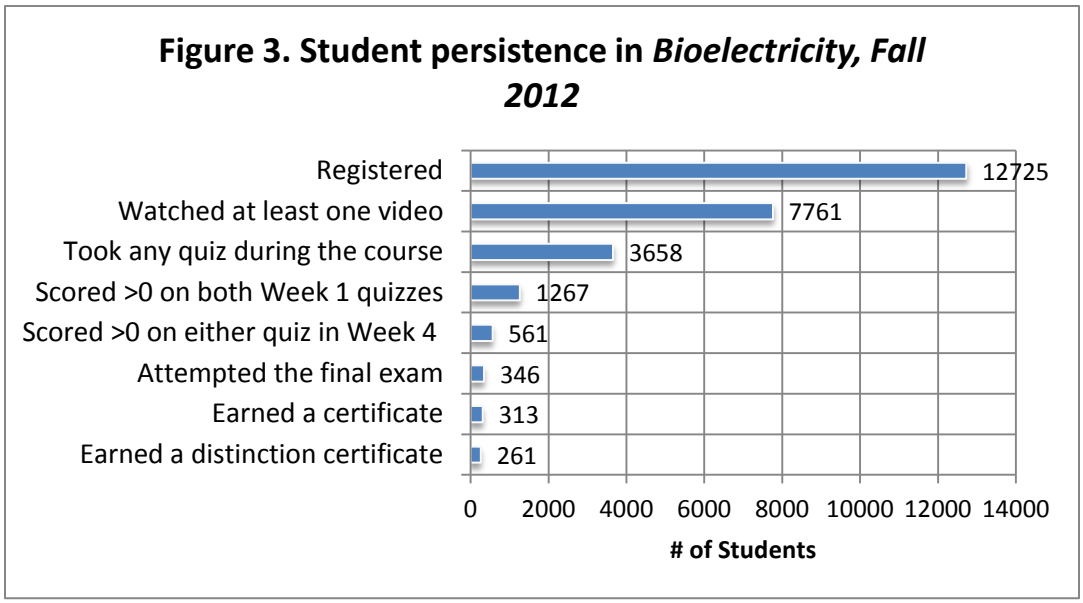
The initial "*Intro to Week 1*" video was viewed over 8,000 times during the entire period the course site was active, including both streaming views and downloads. In total, over 156,000 total streaming views

[6] In early fall 2012 when Bioelectricity was launched, many Coursera students and courses referred to what is now called a Statement of Accomplishment as a Certificate. We have retained this terminology for clarity, but it should be understood to be the same as the term Statement of Accomplishment now in use.

and 179,000 video downloads were recorded. Video viewing measured on a weekly basis provided one indicator of student engagement and persistence. Weekly views declined sharply at first, eventually leveled off at just over 1000 views per week (*Figure 2, Bioelectricity Video Views).*



The level of forum activity and quiz taking behaviors were monitored as a means of measuring student engagement. In a similar fashion to video views, most course activity was at its peak at the beginning of the course. Over 800 unique students posted to the forum, with over 550 contributing during the first week. More than 3600 students attempted a quiz; 3200 of these students attempted a quiz within the first week. Only 1/3 of those 3200 students answered a question correctly on both week one quizzes, and about 700 students earned perfect scores on both assessments in Week 1. Figure 3 (below) represents student persistence and retention in the course.



Ultimately, 25% of students who answered at least one question correctly on the quizzes during Week 1 were successful in completing the course requirements. Approximately 10% of students who attempted any quiz (313 students) completed all course requirements, including 261 who earned an average of 70% on the "B" series mathematical quizzes to meet the "Distinction" requirements.

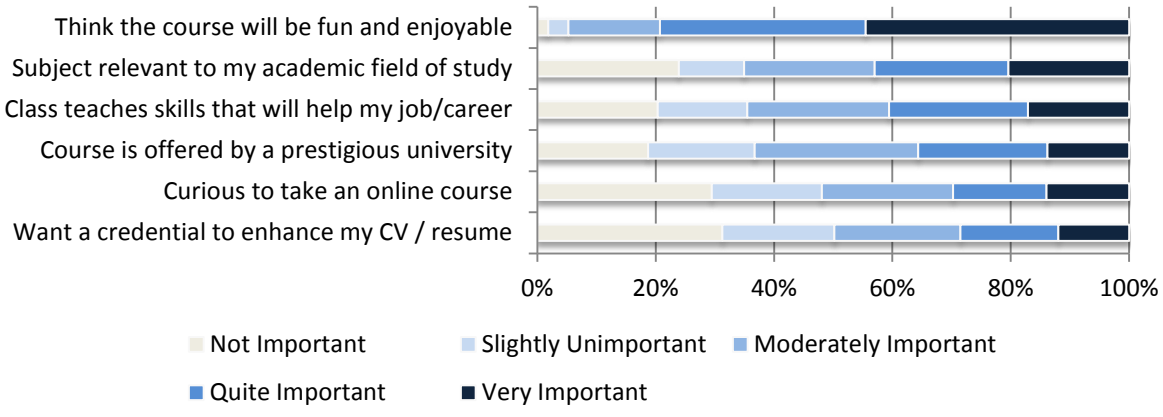
Throughout the course, the discussion forum provided valuable formative assessment data for the instructor and the course support staff. Students provided feedback on content, identified related content in textbooks and web links, and noted technical glitches, motivations for participation, factors impacting success and retention, suggestions for improvement, and a host of other useful issues.

All enrolled students were invited to respond to an optional survey at the conclusion of the course via an email link to an electronic survey (via Qualtrics). The post-course survey had 105 respondents, two-thirds of which were students that earned a certificate in the course.[7] Students provided responses about their motivations for taking the course, some demographic information and responded to evaluative questions about content, platform, instructor and overall experience. Post course surveys repeated some of the pre-course survey demographic items, since different samples of students would opt in to taking the post course evaluation.

Student motives for enrolling, expectations and experiences

Student motivation in the MOOC environment is a significant area of interest to stakeholders at Duke and elsewhere. Pre- and post-course surveys included questions about motivation, and discussion forum comments also included students' descriptions of their motives for enrolling. In response to a set of options on a pre-course question using the template provided by Coursera, fun and enjoyment were selected as important reasons for enrolling by a large majority of students (Figure 4). [8]

Figure 4. Pre-course motivations for enrolling

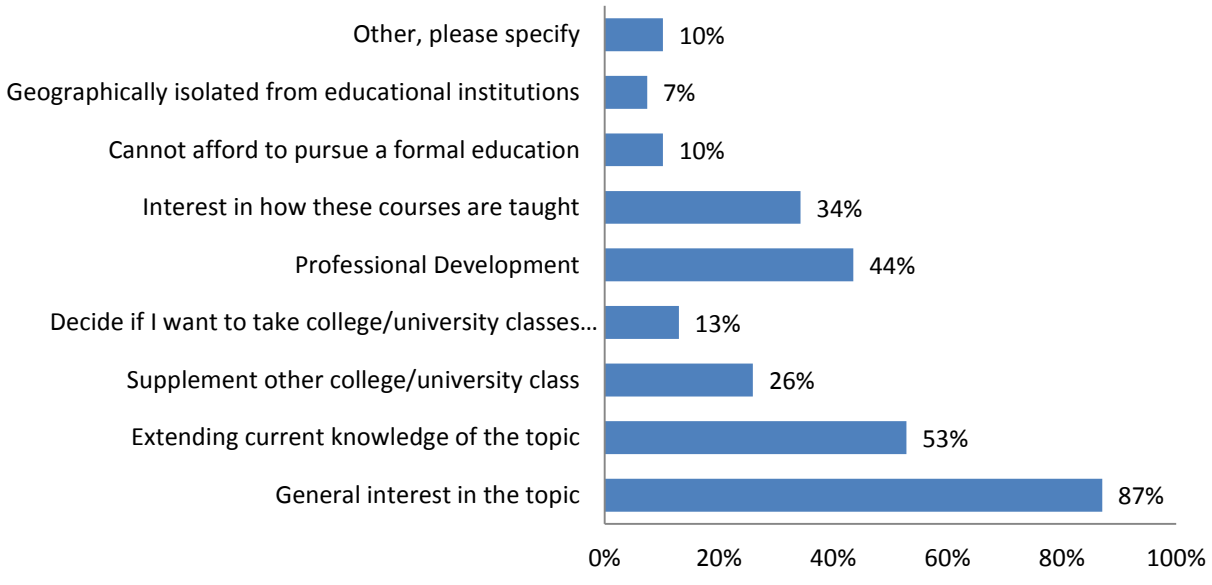


[7] Students who responded to the end of course questionnaire primarily represent the views of those still active at the end of the course, and disproportionately represent the views of students who successfully completed all requirements.

[8] At the time this course was offered, the Signature Track option for verified certificates now available from Coursera had not yet been introduced; it is not yet known whether this option will impact student motivations regarding the importance of the course credential.

On the post course survey, students were provided with a wider range of choices and were allowed to select all applicable reasons. Their responses are summarized in Figure 5, below. (Analysis of 'Other' responses found that these largely fit within existing categories.)

Figure 5. Student motivations for enrolling



Supplementing these categorical responses were comments in the survey and discussion forums. Student motivations typically fell into one of four categories:

- To support lifelong learning or gain an understanding of the subject matter, with no particular expectations for completion or achievement
- For fun, entertainment, social experience and intellectual stimulation
- Convenience, often in conjunction with barriers to traditional education options
- To experience or explore online education

On the post-course survey, students were asked about their initial intentions. Most reported that they began the course intending to view the lectures, do the assignments and get a certificate (72%).[9] A substantial number had only intended to gain an idea of what the subject is about and perhaps hear a few lectures, but in their own opinion did not enroll as committed students (23%). A small proportion of respondents enrolled for some other reason, such as seeing what topics were covered or how a Coursera course is presented (3%). Students were also asked to identify whether they earned a certificate or not (67% yes / 33% no). Not surprisingly, certificate earners reported participating in each component of the course at a higher level than non-earners (Figure 6, next page).

[9] See note regarding "Certificate", page 7.

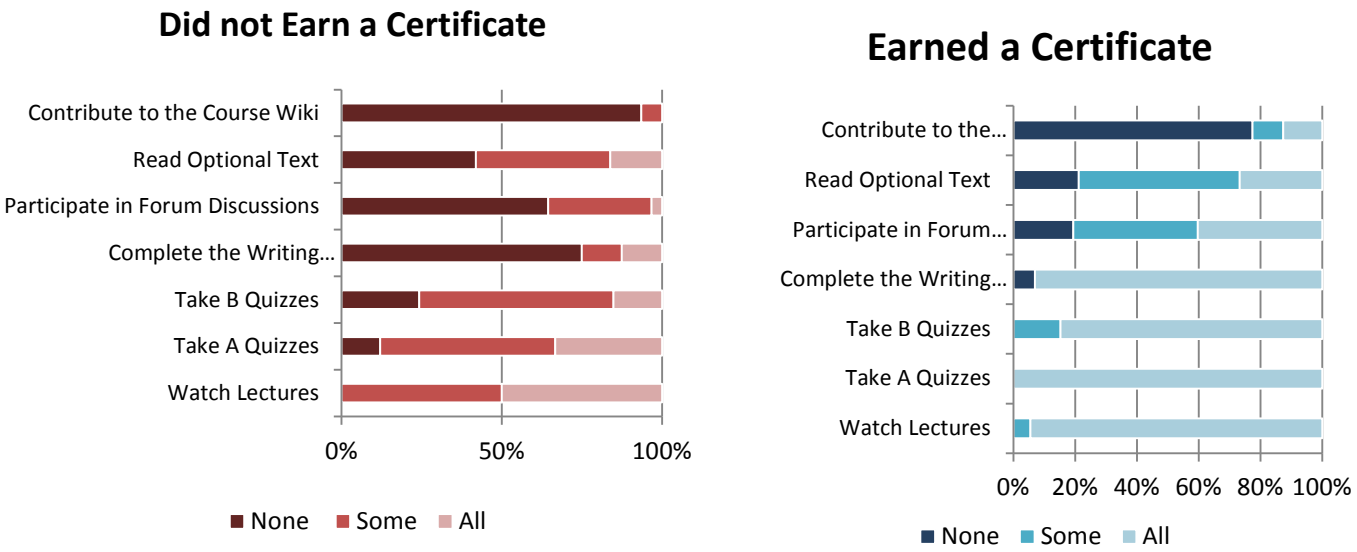


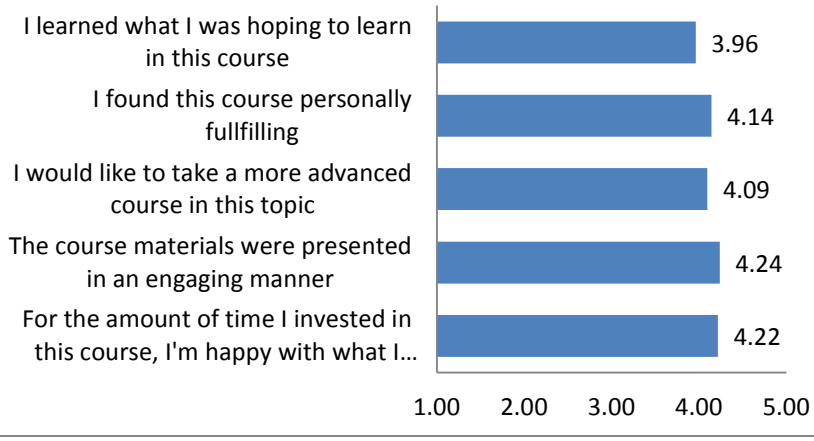
Figure 6. Course activity comparison, certificate earners vs. non-earners

However, among those who completed the survey, half of non-earners did report watching all of the lectures. Course web site analytics also confirm that the numbers of students watching lectures always far exceeded the number of students completing the weekly exercises.

The post-survey also asked students about their satisfaction with various components of their course experience. The survey sentiment was much like the positive feedback shared on the course discussion boards; individuals responding to the survey or posting on the forum were most likely to express positive feelings about the course. On a scale from poor (1) to excellent (7), the mean rating of the students' overall course experience was 5.64; ratings for students earning a certificate were not significantly higher than the sample of non-certificate earners who responded (5.7 for certificate earners vs. 5.5 for non-certificate earners).

Students were also asked the extent to which they agreed with various statements about their experience (1=strongly disagree to 5=strongly agree); a large majority of students agreed with all statements (Figure 7). The group with the lowest mean score *(I learned what I was hoping to learn in this course*) still had 78% of students Agree or Strongly Agree.

Figure 7. Student attitudes about *Bioelectricity*

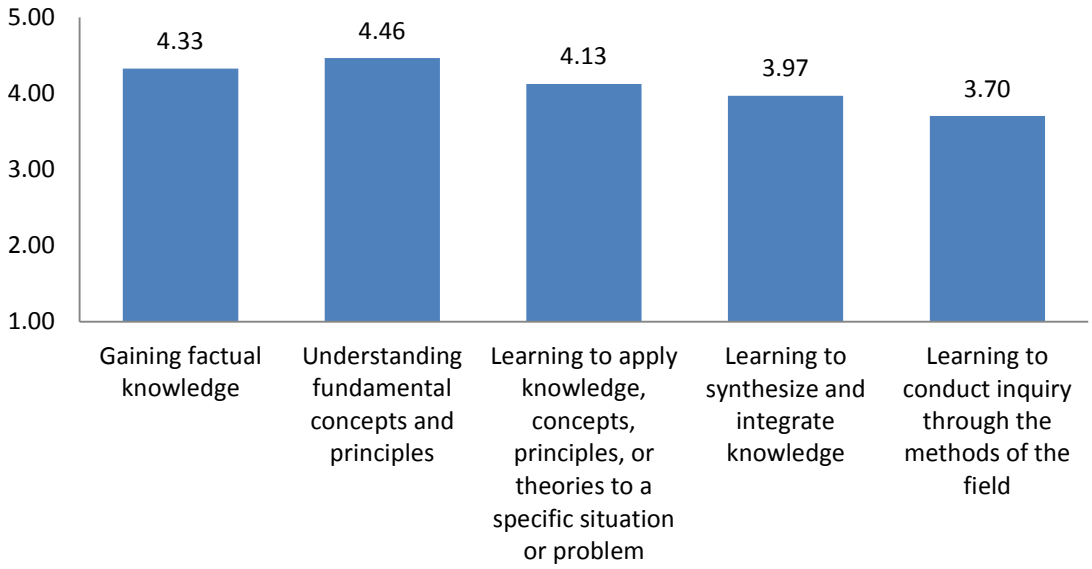


In addition to overall course satisfaction, students reported that they were satisfied with the forums and the instructor (1=strongly disagree to 5 strongly agree):

- Forum discussions with my peers enhanced my understanding of the material (m=4.16)
- The forums were a safe, supportive place to post (m=4.19)
- The organization of the forum was conducive to communicating with my peers (m=4.07)
- The instructor enhanced my understanding of the material (m=4.38)
- I would take another course from this instructor (m=4.25)

Students who had earned a certificate in the course were asked a series of learning outcome questions paralleling those currently used in undergraduate course evaluations at Duke University. Students were asked to judge how much this course contributed to a set of general undergraduate learning objectives using a five point scale, from not at all (1) to very highly (5), including a not applicable option (Figure 8).

Figure 8. Student reported learning outcomes



Analysis of student outcomes in comparison to demographics, motivations, learning goals and course participation factors is ongoing. Also, post-survey respondents who opted in be contacted about the ongoing outcomes of their participation (80%) will be surveyed at a future date.

Factors promoting student completion

Given that the primary motivation for many students was enjoyment or general enrichment, the large attrition rate is not surprising. Students reported a variety of motivations for wanting to complete all course requirements.

- **Formal recognition of accomplishment -** Although the market or educational credential value of this certificate is not yet clear, students cited this formal recognition of accomplishment as a factor in motivating them to enroll initially as well as to persist in completing the course requirements.

- **Professional development -** Based on comments in the post-course survey, many students expected that the knowledge or skills would enhance their professional work, improve job performance or promote their advancement in the workplace.
- **Participation in the forums and other student interaction -** In addition to responses by the instructor and TAs, students frequently responded to one another, encouraged one another and shared supplementary resources. As one student commented, "I'd also like to express my appreciation for the people in the class who are taking the time to lead the math-rusty students like me through the problems. There was no way I could begin to attempt any of the quiz questions until I read the discussion forums. Now I'm feeling confident I can work through these problems…."
- **As a supplement to a credit-bearing course -** Some students were simultaneously enrolled in formal coursework in engineering or a related field which this course was intended to supplement, or planning to enroll in the near future. In addition, twenty students who completed the Coursera course were co-enrolled in Dr. Barr's graduate level Bioelectricity course in Fall 2012. Since the content in the Coursera course was important review material for those students, their scores in the online A and B series quizzes in Coursera were factored into their cumulative scores on the quizzes as part of their grade.

Barriers to student completion

Three significant themes emerged as stumbling blocks to student completion of course requirements.

- **Lack of time / amount of time required -** Many students cited a lack of time as a significant factor which prevented them from completing the course requirements.
    - *"I left the course unfinished because I got caught up with my studies; also, being a med student, I don't have a particularly strong grasp on the physics and math behind the course material and everything slowly started to go over my head. But I did download all the material and I hope to be able to finish what I started in the near future, in my own time."*
    - *"I originally wanted to do all of the course work and obtain a certificate. I am retired, so it doesn't enhance my credentials. Life got in the way of my spending the required amount of time to complete B quizzes within the allotted time. But I so much appreciate Duke offering such outstanding material and Dr. Barr is a wonderful teacher and seems like a great human being, too."*
    - *"I expected to finish the course, but got behind with the quizzes. The quantitative part (math) of the course was harder than expected, but would be manageable if a significant time was spent learning it and the basics behind it."*
- **Insufficient math background and skills -** Many students not able to complete the course specifically cited difficulty with the mathematic requirements, and this topic arose frequently on the discussion boards as well.
    - *"I loved the first week but I too couldn't get past the second quiz of week 1 and I haven't gone back. It saddens me that my math skills or lack of has made me stop."*
    - *"I love the ways classmates are trying to help each other going through lessons and quizzes. I'm here with almost zero Math background and thought I won't be able to do the Math quiz at all, but finally I can do some of them."*

- ***Making the leap from concept to application -*** In most cases the students found the content to be engaging and of high quality. The only substantive feedback that was consistently made by a range of students was the difficulty in applying the lecture concepts in the applied setting of the mathematical "B" series exercises. Students openly discussed this, with many students posting on both sides of the debate, such as in a forum thread entitled "*The quizzes should pertain to what was actually taught in the lesson*" and elsewhere. Dr. Barr engaged in this discussion directly, at one point remarking, "I see close linkages between the questions, the videos, and the subject even though I see now that these are not immediately apparent…" and creating the Hints and Kinks partly in an attempt to guide students in making these connections.

The faculty experience

Overall, the course required more time than the instructor had expected, particularly the amount of time spent interacting with students and dealing with various issues while the course was active. In addition to significant time spent by the TA in monitoring the course forums, the instructor still reported spending hundreds of hours during the eight weeks that the students were engaged with the content. Although much of this time was likely necessary (troubleshooting problems, participating in course planning meetings), in other cases the instructor found the experience enjoyable and willingly invested additional time engaging with the students as they grappled with the material, raised questions and discussed the content. As Dr. Barr commented to the students, **"**Some of the things I like most about our course arise from the Forums--- they exude energy, vitality and diversity. The commentary is penetrating, in places sharp, yet it has an underlying good will that gives it charm."

> *"Creating the course has been a big enterprise, with much more to it than I originally imagined. It is done piece by piece, no one that difficult, but there are a lot of pieces and they should fit together. Usually they have done so (smile). The whole Duke team has worked hard to make Bioelectricity a success. The subject itself is so attractive that if someone has a chance to see it they are drawn to it; our opportunity has been to open a window into that world. Being the instructor for the course has been exciting and rewarding for me, and a big part of its fascination is coming into contact with the much bigger world of talented and capable people such as yourselves who I would never meet in a traditional Duke class."* – Roger Barr, announcement posted to Bioelectricity students

Dr. Barr also required his graduate students to complete quizzes in Coursera as a means of reviewing prerequisite course content and strengthening their skills in applying concepts central to their advanced study. These students reported finding these quizzes time consuming (primarily due to the combination of randomization and the delay between attempts) and did not feel they learned enough to justify the substantial time required; however, Dr. Barr observed anecdotally during the semester that course discussions frequently referenced the Coursera videos and exercises and felt that these students benefitted from the review and performed at a higher level overall during the term than his students in similar courses in the past. In the next iteration of the course, the instructor plans to reduce this delay to one hour to see if this may reduce student frustration; however, he observed that students who are less happy may yet learn more.

Dr. Barr felt that overall the Coursera platform proved its capability to deliver a video-intensive course to a world-wide audience, including support for discussion in multiple languages, automated assessment of individual students, variation of questions from student to student and across multiple attempts by the same student, and in enabling a complex scoring plan. During the time the course was in progress new features were added and substantial improvements were made to the platform that enhanced the course delivery, e.g. in allowing a wider range of mathematical questions to be used. In spite of being a generally robust platform, some technical issues did arise with captioning and scoring that could not be resolved by the instructor or Duke staff and required intervention by Coursera developers. Although Coursera responded quickly to all reported issues and in the estimation of Dr. Barr, "rose to the challenge," technical issues did cause occasional and temporary problems prior to being resolved.

Other Findings

1. *Students clearly valued the dedication of the instructor and the opportunity to take this course.*

Via forums and surveys, students repeatedly expressed feeling respect, connectedness and affection for the instructor. Also, several students participating in other online courses singled out Dr. Barr and his staff as unusually dedicated. Throughout the forums students repeatedly thanked Duke University and Dr. Barr for the opportunity to participate.

2. *The size and diversity of this student population enhanced the course experience for the instructor and the students.*

Online students engaged the instructor and one another by answering questions, extending the discussion through specialized references or personal knowledge, and by their level of sustained, serious attention. The total number of students who completed all course requirements was small in comparison to the number who enrolled; however, this number was very large as compared to campus classes in this subject. Dr. Barr noted that it would typically take him 10 years or more to teach more than 300 students Bioelectricity in its usual face to face format. The instructor not only reached many more students than he would have in a campus course, but he also observed that it was a broader and deeper range of students, many with expertise in topics closely related to bioelectricity. As he noted in a post to the students, "The Forum and the Wiki

Sample comments from students

"Prof. Barr's gentle manner, quiet sense of humour and dedication to answering our questions in the forums have guided me through, and here I am at the end of the course, having learnt so much and given my brain an amazing workout! I am really going to miss sitting down with my cup of tea, in my precious child free moments once a week and hearing 'Well, hello again, this is Roger Coke Barr for Bioelectricity....'"

"I am enrolled in other Coursera classes and I have to tell you that you don't see this level of dedication and interest from other professors or even TA's."

"I just want to start this thread as an appreciation to all the fellow students that have been there for the rest of us….It is through the kindness of strangers that, walking on this path has been so wonderful, fun and learning. It is as standing on the shoulders of giants that one can see further ahead, and all of you have been such wonderful and generous giants."

have contributed hugely to this course --- I love to read them and do so every day. They are a good mode of feedback to the Duke team, identify errors, and even more importantly they have added ideas, links, commentary and all the little things that make the course interesting and real." Student comments echoed this sentiment that the diversity enhanced their course experience. Students co-enrolled in Dr. Barr's campus graduate level course did not report interacting with and become part of the online cohort of learners, primarily due to significant constraints on their time.

3. *A positive learning community was evident in the forums throughout the duration of the course.*

Across a wide range of backgrounds and motivations, the community was positive and supportive of one another throughout the duration of the course. The quality of discussion in the forums far exceeded the instructor's expectations. Also, by the end of the course students active in the forums clearly had established a learning community and a virtual cohort was exchanging information about which Coursera courses they planned to take together next.

4. *Video production did not appear to be a factor in students' experiences or satisfaction.*

Many stakeholders in the MOOC arena have raised questions about the level of video production and the extent to which production quality may influence learning and satisfaction among participants. Students only commented on the substance and content in the videos. Although video characteristics varied, students did not comment on this variation, and viewing behavior did not seem to be influenced by whether the videos were produced in a studio or self-recorded by the instructor.

5. *The evolving course delivery platform and rapid development timeline resulted in a variety of challenges.*

Only 16 weeks elapsed from the time Duke first joined the Coursera consortium to the launch of *Bioelectricity*. Due to the compressed production timeline, this course was produced in parallel with emerging documentation, policies, processes and technologies at both Duke and Coursera. Patience, flexibility and resilience on the part of instructor, CIT staff, and Duke University Office of Information Technology media services staff were key elements in the success of this course. Although the timeline was challenging, systems and procedures established in most cases worked well and were used repeatedly multiple times.

Summary

With only three months to plan and develop its first MOOC, Duke University and Dr. Roger Barr delivered a successful and challenging Bioelectricity course via Coursera in Fall 2012. Hundreds of students successfully completed all course requirements, and many hundreds more enjoyed and benefitted from participation in this course. More broadly, the experience of developing and delivering this course provided useful organizational learning about online pedagogy specific to the MOOC environment which has already benefitted other Duke faculty and has helped Duke develop its infrastructure and expertise in online course delivery more generally.

Appendix A: Duke Online Initiatives Goals

- Promote teaching and learning - experimentation, innovation
    - Course design without constraints of semester, credits, rooms
    - Make better use of in-person time in Duke campus courses by leveraging online content and activities
    - Support interdisciplinary teaching
    - Create modular, repurpose-able content
    - Experiment with technologies for social learning
- Support strategic goals of global outreach, knowledge in service to society
    - Internationalization
- Enhance Duke's reputation
    - Showcase faculty and courses
    - Connect with alumni
    - Highlight Duke to potential students, faculty, donors

Appendix B: Syllabus from *Bioelectricity, A Quantitative Approach*, Coursera, Fall 2012

This syllabus is for the course ***Bioelectricity,*** *A Quantitative Approach*

The course is 8 weeks long. Each week's lectures and questions develop a major theme. The themes have value independently, and---even better--- they lock together in the fashion of a jigsaw puzzle, so that a bigger picture appears as each week is completed and locked into the ones that came before.

Weeks and Themes:

1. **Foundations:** including electricity in solutions
2. **Energy:** pumps and channels that allow membranes to "charge their batteries" and thereby have a non-zero voltage across their membranes at rest.
3. **Channels:** remarkable experimental findings on how membranes allow ions to pass through specialized pores in the membrane wall.
4. **Hodgkin-Huxley model:** The Nobel-prize winning set of ideas describing how membranes generate action potentials by sequentially allowing ions of sodium and potassium to flow.
5. **Axial and transmembrane currents within and around the tissue structure:** including how these currents are determined by transmembrane voltages from site to site within the tissue, at each moment.
6. **Propagation:** How action potentials in one region normally produce action potentials in adjacent regions, so that there is a sequence of action potentials, an excitation wave
7. **Extracellular observations:** The basic principles that allow electrically active tissue to produce time-varying voltages between electrodes located far away from the electrical sources, including a little discussion of the sources of the electrocardiogram.
8. **Transmembrane and Field Stimulation to initiate or control excitation:** A brief glimpse into the huge world of electrical stimulation and how it works, especially with the stimulus electrodes are both outside the tissue to be stimulated.

Every week you will enjoy the new ideas that are introduced, and you also will enjoy seeing how the new ideas link into the earlier ones.

Weekly Lectures

Each of the 8 weeks includes a number of lecture segments, about 2 hours of material in all, divided into about 12 segments. Students report that they like such a division because it allows them to make profitable use of smaller segments of time. Moreover, when a topic proves elusive at first, it can be viewed a second time.

A pdf file showing a set of slide images is attached to the first lecture of the week. This set of slide images is for all the lectures of the week, including the first lecture and all the others for that week.

Weekly Questions

Each week includes a number of questions. It is common experience that when one works on answering a question one thinks about what is asked in a more intense and probing way. For many students, it will be working on the questions that will give the most reward in terms of understanding, so I hope every student works on the questions to the greatest extent possible.

Within the capabilities of the computer system, it has seemed to be best to call most of the weekly questions "quiz questions" as that category seemed to best provide the capabilities that were needed --- answers checked, multiple tries on similar but not identical questions, and recorded scores. If you would rather think of the questions as homework questions or some other name, please do so. They are there as an aid to learning, and you will see that in some cases ideas are introduced first in the questions, rather than in the video lectures, although mostly the first mention is in the videos.

Most weeks there will be questions asked in a multiple choice format (identified by suffix A, as in quiz1A) and then other questions that ask for mathematical answers (suffix B, such as quiz1B). Every student is well qualified to do the multiple choice questions. The mathematical questions can be figured out by anyone too, but students who have more mathematical experience likely will do them more quickly.

By the end of week 6 you will be asked to submit of a paragraph describing a particular kind of bioelectric signal. The specific text of the assignment is expected to be available at the start of week 5, but essentially the question will ask you to identify one kind of bioelectric signal and tell some things about it. When you see the assignment and know the details, focus on one kind of bioelectric signal that interests you. Then, between week 5 and the end of week 6, please write the paragraph requested, using the kind of signal you find interesting as the subject of your text. In week 7 an assignment will ask you to read and score the submissions of several other students, and make comments. You will find these assignments not too hard and very interesting.

Responses to this assignment will be evaluated by the new peer-assessment method. The core idea is that every student will be asked to write a paragraph. Then, after the closing date for submissions, each student is asked to score the submissions of a few other students to judge if some particular points are included. More details will be forthcoming as week 7 approaches. I think you will like this assignment because it is not hard to do yet very interesting to see the range of topics selected by other students.

The weekly questions do not reflect all the aspects of the video presentations, so I hope that everyone takes time to listen to the video segments with patience. These videos give a range of perspectives, facts, and opinions that are easily acquired just by listening and that may not be available from any other source.

Transitions

The transitions from one week to the next are set up in the Coursera system to occur at 3pm Eastern USA time. At that time submissions for the preceding week end and submissions for the following week begin. While older video segments remain available, videos for the next week in the course become available. In the course as a whole, material is organized by week, and the transition for everything is at this one time each week.

This plan has been adopted taking into account the views of students in previous Coursera courses, many of whom wanted to work on assignments on weekends. Making the transition at 3pm Monday Eastern US time allows students around the world to have the full weekend for course work, if their schedule makes their weekend the best time. It also allows the transition to occur during regular business hours for those of us in charge of the course, so that if there are loose ends from the previous weeks or some problems associated with the material for the new week, we know about it during hours when most of the personnel who are part of course management will be available.

Variability of questions

Please be aware that the software for asking questions that is provided by Coursera encourages random selection of questions. Depending on how the question is set up, the randomness may cause changes in individual numbers within questions, parts of questions, or the sequence of questions. Entire questions may be replaced by other questions. That means that when you discuss a question with someone else, it is not meaningful to say "question 4" because that student's question 4 likely is different from your own.

Final Exam

In week 8, the final week of the course, there will be the regular week 8 videos and weekly questions. Additionally, some additional questions will become available, and these will be identified as final exam questions. These questions will be taken from earlier assignments, but not necessarily asked in the original order. There will be more restrictive rules regarding final exam questions. More details will become available as week 8 comes closer.

The Forum

Because of the large number of students enrolled, we are not going to be able to respond to questions from individual students. The good side is that Coursera has a sophisticated Forum capability, and we will make full use of it.

Please post your questions, comments, technical issues, or other items in the Forum. Please look around at the various headings and threads and place your comment where others with related interest will see it. Experience has shown that in most cases other students will know the answer to most any situation and respond with good information or advice. In those rare cases where the teaching assistants or instructor feels a further response is needed, we will respond publically. The response may be in the section of the forum reserved for us, though if urgent or major issues arise, they may be covered in an email. Items that carry forward from one week to the next may become a topic in the weekly announcements.

The forum also allows and encourages social interactions among students. Please introduce yourself and participate further as best suits your situation. We will leave what happens here mostly up to you, the students in the course, knowing that in other courses student social interaction has been extensive, friendly, and positive. Please be mindful that students come from many different places, geographically and culturally, and do your best to address others politely and with respect.

Discussion of quiz questions on the forum

It is fine to discuss the quiz questions on the forum as far as the underlying ideas, links or references, and in general how to go about answer the questions. However, please do not give specific answers. For example, do not say "the answer to number 3 is 77." If you do that, it takes away the thrill of discovery from another student. More seriously, giving specific answers is a breach of the ethical code for the students in the class.

Reference text

This course is loosely based on the textbook *Bioelectricity, A Quantitative Approach* by Robert Ploney and Roger Barr, 3rd edition, Springer publishing. The book is available from many booksellers and is in many academic libraries. The course relates to the book in that the weekly themes develop the same major ideas that are developed in the chapters of the text.

The text is more comprehensive and more detailed, especially in terms of the mathematical depth, and also covers additional topics that are not included in the course. In that regard, I like the course better for a newcomer, in that it gets to the main points in a leaner, quicker and more streamlined fashion. Other students who want more depth will prefer the text, because they will prefer the more comprehensive approach.

My intention is for a student to be able to complete this course, including all the questions, without having to have a copy of the book. At the same time, a serious student might like to have a copy of the book to use as a supplement or as a reference.

Suggestions on doing well in terms of getting a higher score

Every student has a different "best" way of learning, so it is not for me to say what is best for you. If I were doing the questions, however, I would go to the quiz segment first and try an answer before listening to any of the videos. Then I would listen to the videos with my wrong answers in mind, and correct them along the way. If one does quiz first the video second, however, one has to be careful not to become too focused on the questions, as one wants to learn about the whole subject, not simply those few points that come up within a relatively small number of questions.

Special invitation to teachers at all levels

All teachers are enthusiastically welcomed to this course, and especially teachers of high-school students and younger children,. Bioelectricity is important to every one of us --- it is how we as people really sense things, move, and think --- and it is interesting stuff. My grandchildren (and the oldest one is only 4 years old) love knowing how the dots (action potentials) run down and up their arms from their brain to their fingers and back again.

Bioelectricity has for too long been kept in a sort of box of professional secrets, a box where only a few people were allowed to peek in. Let us work together to liberate Bioelectricity from that box. If you can't do that because you are limited by your imagination, just ask a 4-year-old to help you (smile). All of electricity is interesting, in part because it seems mysterious and invisible, and for many of us, bioelectricity is the most interesting kind of electricity of them all.

Thank you for joining the course

As you know, this course is part of a grand experiment. No doubt things will evolve and improve in ways we do not yet imagine. Nonetheless it is fun to be a part of something at the beginning, as is true for both you and me. Thank you for participating. Let us do our best together to make the experience both productive and enjoyable.

..rcb