Musings on MOOCs

Jim Fowler and Tara Smith

MOOCs (massive open online courses) are causing a revolution in higher education today. What will be the impact of this revolution on mathematics teaching in colleges and universities? The *Notices* is hosting a discussion of MOOCs, which began in the November 2013 issue with the Opinion column "MOOCs and the future of mathematics" by Robert Ghrist of the University of Pennsylvania. The first installment of the discussion appeared in the January 2014 issue and continues in the present issue. The *Notices* invites readers to submit short pieces (800 words or less) on the subject of MOOCs in mathematics. Please send contributions to `notices-mooc@ams.org`.

James Fowler

With a team at Ohio State, I've created two MOOCs, namely Calculus One (which first ran in the spring of 2013) and Calculus Two (which first ran in the fall of 2013). More are on the way. Both MOOCs debuted on Coursera, but much of the content is also available on iTunes U and YouTube and has been used to "flip the classroom" at Ohio State. MOOC content can be deployed for a variety of purposes.

I agree with what Robert Ghrist wrote in "MOOCs and the future of mathematics" [*Notices*, November 2013]. Ghrist emphasizes that MOOCs make possible experimentation with the exposition of mathematics; I'll emphasize that MOOCs are also experiments with assessment. The basic question is this: how do we get more people to do more homework? For our MOOC, we built an adaptive learning platform called MOOCulus—a play on "cow-culus". MOOCulus provides randomly generated interactive calculus exercises with hints. Correct and incorrect responses and requests for hints are used to estimate the student's present level of mastery so that, as the student masters a particular topic, the student progresses to a new challenge. The hope then is that each student is actively working on problems that are at the appropriate level to help that student grow.

All these students doing all these problems means we have a lot of data on student learning. Armed with this data, Bart Snapp, David Lindberg, and I are examining how a student's experience with MOOCulus relates to that student's performance on traditional in-class assessments.

That we are collaborating on MOOCulus is significant. MOOCs are usually said to be "open" in the sense of open enrollment, but "open" might also mean "open source". The source code and other materials for our MOOCs are available in a public repository, so anyone can look behind the scenes to see how we've built what we've built. Improvements to our code have come not just from faculty elsewhere, but also from our students. In short, MOOCs make teaching collaborative and public—just like research.

Collaboration is the whole game. MOOCs are only about technology insofar as technology facilitates the development of communities. Those communities are not just communities of learners. They also include communities—like this one facilitated by the *Notices*—of teachers and researchers. In the past, Ghrist's innovations might have been known only to the people at his home institution, the University of Pennsylvania, but Ghrist has, in a sense, published his teaching, and that publication makes possible a discussion about his innovations.

Tara Smith

My daily professional routine is not markedly different from that of my advisor, or indeed of his advisor. I teach classes, mentor graduate students, and immerse myself in my research and writing, collaborating with others or on my own. Classroom instruction, supported by recitation sections often led by a TA for large classes, has continued to be the norm for most of us. We've embraced pedagogical changes (or tried and rejected them in some instances): inquiry-based learning, cooperative learning, graphing calculators, computer algebra

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DOI: http://dx.doi.org/10.1090/noti1083

systems, tablets, clickers, etc. Still, collegiate math instruction has continued primarily to consist of an instructor on site delivering content to his or her students, running problem sessions, assessing mastery via completion of homework and performance on exams, and interacting directly with the students three to five times per week.

Lately, however, as I converse with current and prospective doctoral students in mathematics, I have begun to wonder what the rapidly expanding menu of mechanisms for delivering mathematics content—most notably MOOCs—portend for the future of our profession, our students, and our community. How substantially will the careers of this next generation of mathematicians differ from those of us who have been in the field for twenty, thirty, or forty years? What will the daily professional life of the academic mathematician look like in another five, ten, or twenty years?

All we know for sure is that it is likely to be different in substantive ways. The differences will be driven by the rapid expansion of alternative ways to deliver content as well as the harsh economic realities facing higher education. We might find ourselves confronting the critical question Robert Ghrist posed in his piece about MOOCs in the November 2013 *Notices*, "Why do mathematicians exist?"; surely we will at least face the question, "Why should mathematicians be hired by a university?" We need to answer compellingly if academic mathematicians are to continue to exist in significant numbers across many institutions.

What of value do we offer? At many colleges, the justification for sizable math departments is the need for faculty to teach service courses that deliver basic, fairly low-level mathematics content and skill instruction to students in other disciplines who need to have some facility with mathematics as a tool. What is it that our physical presence on campus and in the classroom provides that cannot be provided, perhaps substantially better, by having a student watch a YouTube video starring a skilled lecturer and subsequently be evaluated by a computer-generated assessment? If you believe, as I do, that something magical happens in the personal interaction between instructor and student, something that takes learning and understanding to a deeper level, then how do we demonstrate that? How do we ensure that it happens consistently in our work with students, and how do we persuade those who pay the bills that the added value is worth the greater cost? What formats make sense for faculty-student instruction in light of the ability to get content delivered inexpensively or for free via online sources? Do we move away from lectures and toward a system of tutorials? Flipped classrooms? Can we teach students more efficiently and cheaply by taking advantage of new resources for mass instruction and content? If so, how? And if so, how do we continue to justify the same number of faculty, or will we inevitably be downsized? What would downsizing do to the research climate and opportunities for graduate students?

With the potential for excellent delivery of mathematical content for very low cost, the opportunities for those who previously had no access to such instruction have grown dramatically, which is exciting from any perspective. However, if there is value in more personal delivery, will some who previously had access to that now lose access because the cost of providing it is so much greater than the inexpensive options? We might be moving toward two distinct systems of instruction in higher education. In the first would be students who are prepared for and can afford access to the elite institutions whose faculty are well-funded research mathematicians with some degree of teaching expectation; they would be instructed via MOOCs and other online options, supplemented by classroom and tutorial instruction provided by active researchers and their graduate students. In the second system, students would have their math instruction provided solely by online sources and math tutoring offices staffed by adjunct faculty, perhaps overseen by one or two regular faculty charged with maintaining standards and quality.

I have no answers, but there is no shortage of questions. We do indeed live in interesting times.