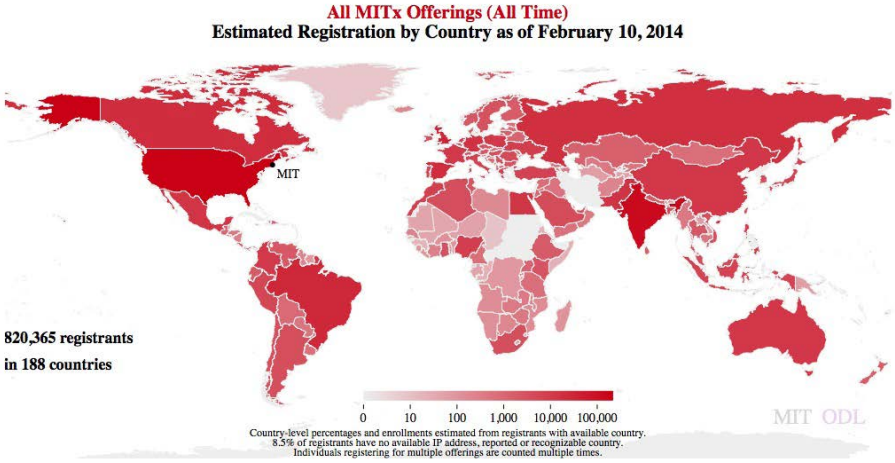
XSeries: a new phase in online education for MIT

by Lauren J. Clark



MOOC datasets from the first 17 edX offerings, along with accompanying visualization tools, were released by MITx and HarvardX, and provide an intuitive interface for accessing enrollment and demographic data. See: Office of Digital Learning: http://odl.mit.edu/insights/

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Online education has entered an exciting new phase, and MIT's Department of Electrical Engineering and Computer Science (EECS) is leading the way.

EECS has developed "Foundations of Computer Science," one of the first two certificate-granting courses for MITx, the Institute's massive open online course (MOOC) effort. It consists of a sequence of related modules on the edX platform, which MIT launched with Harvard University in 2012. The Institute laid the foundation for edX a decade earlier, when it began making all of its course materials available online, for free as part of the OpenCourseWare initiative.

The sequences, called XSeries, represent a new approach to MOOC instruction and certification across integrated offerings more expansive than the individual courses that have thus far defined the MOOC landscape.

"These sequences are an opportunity for MIT to both explore how subjects can be addressed in depth through the MOOC format and to better understand student interest in various types of certification," says Anantha Chandrakasan, the Joseph F. and Nancy P. Keithley Professor of Electrical Engineering at MIT and head of the EECS Department. "XSeries sequences allow our departments to reimagine the building blocks that structure teaching in our disciplines for the digital environment."

Just like on-campus EECS courses, "Foundations of Computer Science" introduces key concepts of computer science and computational thinking. After viewing video lectures by MIT faculty, XSeries students apply these concepts and build their engineering skills by completing software and hardware design problems. Additionally, they test their understanding by taking a series of exams.

To create the XSeries, EECS faculty divided three undergraduate courses into seven shorter modules that are more accessible to online learners—most of whom are studying during time off from jobs or school. The faculty estimate that the XSeries, whose post-introductory modules are still under development, will take two years to complete.

"It's providing a great opportunity for people to learn about computer science and to launch themselves into the field," says John Guttag, the Dugald C. Jackson Professor of Computer Science and Electrical Engineering, who oversees the first two XSeries modules, "Introduction to Computer Science and Programming in Python" and "Introduction to Computational Thinking and Data Science." He adds, "The feedback is almost all highly positive. It is very gratifying."

The XSeries format allows EECS instructors to experiment, says Ana Bell, a lecturer who has taken a lead role in transforming EECS residential coursework to the digital world. For example, in one of the initial modules, "We added an extra section and problem set on clustering algorithms," Bell says. "These algorithms can be applied to many real-world problems that are associated with 'big data.' We want students to understand how to make sense of such data—be it from social networks, biology, the financial industry—rather than to think of it as a popular buzzword."

Importantly, MITx users include MIT students. By making use of online courses that mirror their residential offerings, they can learn at their own pace. EECS senior lecturer Chris Terman says that when he helped adapt "Circuits and Electronics" for MITx in 2012, he and his fellow instructors also used it to teach their on-campus students that semester.

"The students cited a number of advantages," he says. "They liked the online lectures, because they could play through the things they didn't need to think heavily about, but replayed a

number of times the things they hadn't quite gotten. We ended up doing a sort-of flipped classroom, because we held office hours for questions [the students] had."

"Flipping the classroom" means that students first encounter new material outside of class, usually via reading or video lectures, and then use class time to do the more challenging work of assimilating that knowledge, through problem-solving and discussion, for instance.

Terman and his fellow EECS instructors tend to look beyond this concept, which, like "big data," has become somewhat of a buzzword. "The most interesting outcome will be when we get to a place that's really different than packaging up what we do now," he says.

That's where research comes in. MITx is, after all, a quintessential Institute endeavor in that it blends technology, teaching and research.

Rob Miller, an EECS professor who heads the User Interface Design Group at the Computer Science and Artificial Intelligence Laboratory, estimates that about 80 percent of his researchers' projects focus on online education, including edX and MITx. "Part of the larger idea behind edX is about both teaching the world and studying how to teach better," he says.

PhD students, postdoctoral candidates and SuperUROP students in Miller's group are studying, for example, how to make video lectures more effective at teaching, how to develop self-generating tutoring systems based on students' trial-and-error problem solving, and how to improve in-class activities that will be key to the future of flipped classrooms.

Miller is also developing upcoming modules for the XSeries based on a residential class he teaches called "The Elements of Software Construction."

"It's just as useful," he says, "to actually be teaching courses ourselves" as it is to mine their data for research.

EECS and physics professor Isaac Chuang shares Miller's views about the significance that the XSeries and edX hold for "teaching the teacher." Last year, he co-led a joint MIT-Harvard study of courses on edX that offered new findings on how students engage with MOOCs.

"The story hidden underneath this series of reports may be this," Chuang concludes. "Institutions like ours are coming to appreciate how cross-institutional educational collaborations involving many students and many courses can open new routes to understand and improve student learning—making a difference around the world and back here on campus."

Further reading from the Office of Digital Learning, the MITx Working Papers: http://odl.mit.edu/mitx-working-papers/

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The tale of 6.041 and 6.341 and their respective "x's"

The world is full of uncertainty: accidents, storms, unruly financial markets, noisy communications. The world is also full of data. Probabilistic modeling and the related field of statistical inference are the keys to analyzing data and making scientifically sound predictions.

Over the 50 years that "Probabilistic Systems Analysis and Applied Probability" (6.041) has been taught in MIT's Electrical Engineering and Computer Science Department, the course has evolved. Recently, it became an offering on MITx, attracting roughly 20,000 online learners from around the world.

Called "Introduction to Probability - The Science of Uncertainty" online, 6.041x equips students with the models, skills, and tools that enable them to analyze data and think probabilistically.

EECS professors John Tsitsiklis and Patrick Jaillet teach both the residential and online versions of the course. Tsitsiklis, the Clarence J. Lebel Professor of Electrical Engineering and associate director of the Laboratory for Information and Decision Systems, says it is relevant to a much wider audience: "The class is targeted not just to EE (Electrical Engineering) students. For example, biologists need probability tools more and more."

The tale of 6.041 and 6.341 and their respective "x's"

The online class offers the same content and is just as challenging as the residential class. Tsitsiklis and Jaillet, the Dugald C. Jackson Professor of EECS, videotape their lectures in the form of a sequence of short clips interspersed with concept questions and simple exercises. Students have to solve the problems on the spot, which provides them immediate feedback. In addition, they have access to problem-solving videos, mostly recorded by EECS graduate students that correspond to the recitations and tutorials in the residential course.

"We're more ambitious than the typical undergraduate probability class," Tsitsiklis says. "We're different from a class that gives an overview of problems and ideas. We aim to provide the crispest way of explaining the concepts."

He is intrigued by teaching through a new medium, which can appeal to students with various learning styles. "Some people prefer to learn by reading a textbook. Some want the encouragement of chatting with an instructor. We hope this medium (MITx) will be perfect for some people."

Those who complete 6.041x will be able to successfully apply the tools of probability theory to real-world applications or their research.

This article was adapted from a Jan. 29, 2014 MIT News story written by Sara Sezun and Steve Carson, MIT Office of Digital Learning.

6.341x Flips the Classroom

New MITx course could transfer innovation to other online classes

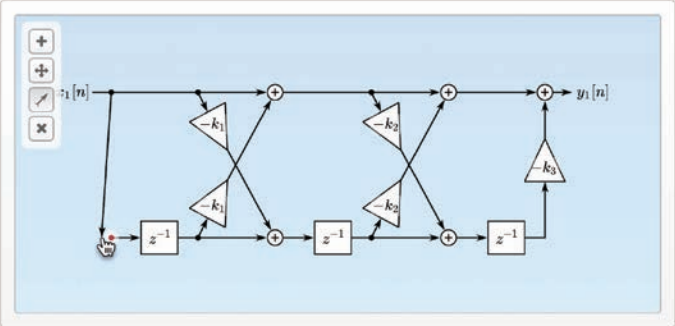
This fall, the first EECS graduate course will launch on MITx. "Discrete-Time Signal Processing" (6.341x). This course, based on the residential offering of the same name, teaches the digital signal-processing technologies on which modern computation and communication systems depend.

Ford Professor of Engineering Alan Oppenheim and Dr. Thomas Baran developed the course after successfully using the MITx online learning platform to innovate the way that 6.341 is taught residentially. While they structured the residential course in the traditional style—two weekly lectures, weekly recitation and problem sets, plus projects and exams—they introduced new features that turned out to be highly effective. A number of enhancements to the online platform were also developed. These new features were highly effective and will be incorporated into MITx for use by the 6.341x development team and potentially by others for a variety of online classes.

During lectures in the residential course this past Fall semester, students used hand-held clickers, i.e. polling technology, to answer in-class questions anonymously. For example, Oppenheim frequently put a problem up on the screen and ask the students to choose the correct answer or indicate that they could only guess. A histogram of the class results would then immediately be projected on screen.

"That's instantaneous feedback to me and to them," Oppenheim says. "My teaching style has always been very highly interactive. I need feedback from the class as to how they're relating to the material. [The students] loved the in-class questions which provided both a short pause to digest a concept, and immediate feedback. They felt it was a tremendous enhancement to the teaching."

EECS graduate student Anuran Makur commented that "The in-class questions gave students an opportunity to gauge in real time to what extent they had understood the material presented in the lecture." He adds, "The anonymity of using the clickers encouraged the majority of the class to provide an answer without fear of being singled out." All of the in-class questions plus many additional ones were typically posted for the class ahead of time but without autograding. Following the lecture the MITx autograding was activated for those problems so that the students could then revisit them with the autograding feedback, says Oppenheim.



Screen capture of a 6.341x student inputting a signal processing system into the platform for auto-grading. Courtesy Tom Baran

The class also used MITx for online evaluation of both the weekly problem sets and the course projects in order to provide immediate feedback to the students as they were working on the assignments. The MITx autograding platform was augmented with an online text box in which students could provide explanations of how they arrived at their answers. "Utilizing the MITx platform for enhanced autograding of the online questions, homework and projects was universally applauded by the students. The students also made use of an online discussion forum that was very actively managed by a teaching assistant.

"This experience has radically changed the way I think about teaching," Oppenheim says. "It will be an exciting educational adventure as we explore the many new ways of leveraging online resources for enhancement of residential teaching."