Internet startups look to reinvent higher education

Massive open online courses promise a convenient, low-cost experience, but high dropout rates threaten to slow their growth.

In what was a banner year for online education, 2012 saw more than 2 million people register for about two dozen college-level online courses. An Introduction to Physics course launched last summer drew more than 37 000 people, and that's eclipsed by several other offerings that have each attracted more than 200 000 registrants. In 2013 enrollment in so-called massive open online courses, many of which are taught by professors from prestigious universities, is expected to rise, with more than 250 such MOOCs being planned or already in session.

Massive open online courses are a timely solution to more than two centuries of stagnancy in higher education, says Anant Agarwal, an electrical engineer at MIT and president of edX, a company that solicits and hosts MOOCs. For traditional on-campus education, he says, "class attendance is dropping, research is showing that lectures are not very effective, and at the same time, student debt is rising." With MOOCs, anyone with an email address can take a college-level course at no cost. Students successfully finish the course by passing a series of quizzes and exams; they receive a certificate of completion but in most cases no academic credit.

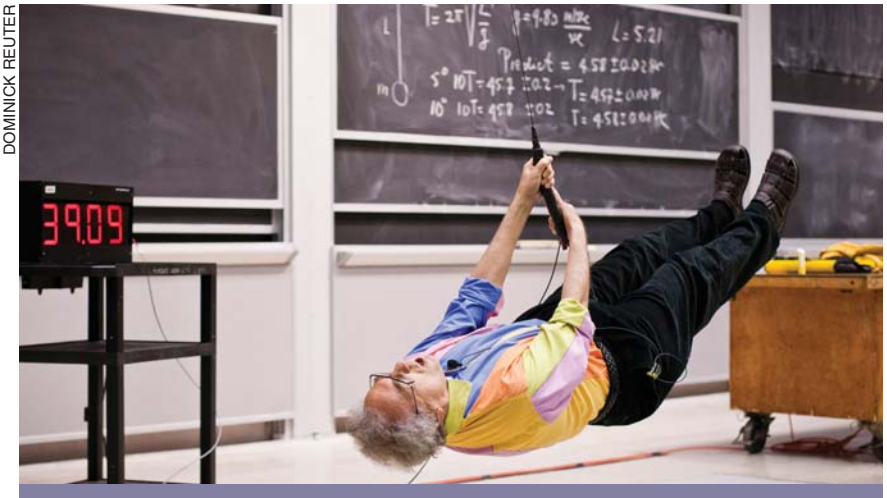
But some physics educators say once you get past a MOOC's massiveness, there's not much that's revolutionary about them. "The weakest part of the [educational experience], the lecture, is what's now being offered for free," says Michael Marder, a condensed-matter physicist at the University of Texas at Austin (UT Austin). Moreover, with many course completion rates dipping below 10%, MOOC companies are scrambling for incentives—beyond a piece of paper—to make their free courses worth students' time and effort.

Thumbs up, thumbs down

The free MOOCs are riding a wave of enthusiasm from bullish education investors and enterprising universities. Two of the leading MOOC companies, Udacity and Coursera, have each received more than $15 million from venture capital firms. Both companies were founded by Stanford University professors. The not-for-profit edX was seeded by $30 million each from MIT and Harvard University. All three companies were launched in early 2012.

Already, Coursera and edX have successfully recruited long-term university partners that have submitted several courses to the companies' MOOC platforms. Coursera has 33 partners, some of them international, including the

DOMINICK REUTER



Riding a pendulum bob to demonstrate mass-independent periodicity is just one of MIT professor Walter Lewin's unconventional teaching techniques that have drawn a crowd, both in class and on YouTube. An Electricity and Magnetism course featuring Lewin's lectures made its debut last month on edX, a nonprofit platform that produces free massive open online courses.

Hebrew University of Jerusalem and the Indian Institute of Technology Delhi. In addition to its founding members, edX so far has scored four partners, among them the UT system, which put up $5 million toward platform development when it joined. And the recently launched, UK-based MOOC platform Futurelearn, a spinoff of the for-profit online Open University, has already signed up 12 UK universities. Udacity is an exception among the free MOOCs; it primarily recruits freelancing professors and full-time, in-house professionals to design and teach the company's offerings.

Existing MOOC platforms share a similar design. Udacity's Introduction to Physics course contains a "Classroom" section, which has a series of one- to two-minute lecture and tutorial video modules; a "Wiki" section that catalogs text transcripts for each module; and a "Forum" section that allows students to submit and answer questions and rate each other's responses thumbs up or thumbs down. Some MOOCs, like edX's Circuits and Electronics course taught by Agarwal, also feature digital textbooks and interactive labs. New courses, which proceed week by week, generally last between five and eight weeks. Archived courses can be accessed at any time, consumed at any pace, and supplemented with new or updated material.

Science and engineering courses are well suited to MOOCs, says Agarwal. For lab-based courses, he says, edX staff are working on video-gaming technology that could simulate experiments (see the report on educational video games in PHYSICS TODAY, April 2012, page 27). For example, the edX course Electricity and Magnetism includes methods developed at MIT to visualize and animate electromagnetic fields. Coursera offers 23 physics-related MOOCs that cover such topics as cosmology, nanotechnology, and nuclear science. Among edX's physics-based offerings are classes on quantum mechanics and quantum computation and on solid-state chemistry.

"I think society is ready for the possibilities of this technology [for] transforming higher education," said Wallace Loh, president of the University of Maryland (UMD), a Coursera partner, at a university-sponsored forum on MOOCs in November. The decision to join a MOOC platform will be driven in part by the political and economic climate that is keeping university budgets flat at best and forcing them to "do more with what they already have," he said. Other than the cost of giving MOOC professors the semester off from regular teaching duties, "it doesn't cost us much to participate," says Patrick O'Shea, UMD vice president for research. "It's our job [in academia] to be the risk takers. We see [MOOCs] as an experiment worth doing."

Headhunting talent

Like other internet startups, MOOC companies look to earn revenue from their massive user base by charging for premium or add-on services while keeping the core content free. For many MOOC students, however, a certificate of completion with no career or academic value has not been incentive enough to finish the courses they signed up for. The dismal completion rates are an indication that any focus on the numbers of registrants is "seriously misplaced," says atomic physicist David Pritchard, who heads the Research in Learning, Assessing and Tutoring Effectively group at MIT. "The number of certificate earners is a far better measure of the amount of education happening."

To entice students to complete their courses, Udacity and Coursera have launched career services that match high-performing students who opt in and employee-seeking companies that pay in. Other monetization options being considered include charging students for virtual private-tutoring sessions and selling access to anonymized and aggregated user data. In the case of edX, whose software is open source, universities may be billed for technical support in setting up their own local MOOC platform.

Universities are also looking to cash in on potential MOOC revenues. California's San Jose State University, which has three math courses on Udacity, and the UT system were among the first to announce that, for a fee, their students will be able to earn college credits from select MOOCs. Other universities are joining an initiative called MOOC2Degree, which converts their core entrance courses into free MOOCs with the hopes that students will continue in a degree program.

Universities may use their MOOCs to attract talented students from other parts of the world, says UMD physics professor Victor Galitski, an instructor for Exploring Quantum Physics, which will debut on Coursera this month. Beyond financial gains, another benefit MOOCs offer academia is a large data set for educational research. For example, institutions that join edX are asked to appoint faculty to collect and analyze

data on student learning—findings that can then be applied to improving the on-campus educational experience, says Agarwal.

A large number of students taking MOOCs live in developing and emerging countries. In those regions, "MOOCs can have a big and important impact," says Fernando Quevedo, director of the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy. This year the center will post lectures online from its recently disbanded Diploma Programme in Basic Physics, which brought underprepared postgraduate students from developing countries up to speed for entrance into math and science PhD programs. Quevedo has commissioned a resident scientist at the center to evaluate MOOCs as replacements for that diploma program. "I'm a big fan of putting course content online," he says. "It would be unwise to have the technology available and not exploit it."

Some physics educators see MOOCs as a possible substitute for lectures in the "flipped classroom" model, which serves up lectures online and reserves class time for activities and problem solving. Last fall UT Austin particle physicist Sacha Kopp, who has submitted two course proposals for the edX platform, taught a flipped Introduction to Modern Physics course to some 300 physics majors. Prior to class, students were expected to watch a set of learning modules—lectures that Kopp says he videotaped at his kitchen table—and answer a set of questions. In class, Kopp would briefly review the module material, administer quizzes, and facilitate small-group problem-solving sessions.

"The flipped classroom was a welcome change because it solves the problem of not immediately understanding the material during a lecture," says Kopp's student Evan Ott. "We could rewind the online lecture [and read] the in-class notes online" after class. Classmate Allyson Rice says the problem-solving sessions in class addressed her biggest complaint with traditional physics courses, that "there's so much time spent in class deriving equations." The convenience of the online lectures was "nice," she adds, "but, for me, I don't think they made much of a difference."

New technology, same goals

"All these ideas about the value of having students watch lectures online are based on an antiquated view of learning" that has been discredited by physics education research, says physics Nobel laureate Carl Wieman, who has served as chair of the Board on Science Education at the National Research Council. "Any sort of authentic measures of learning of expertise, such as testing students' ability to apply a physics concept in a new context, [will show that] lectures, no matter how entertaining and demonstration filled, result in dismally small amounts of learning."

But if done right, "online education can easily be more educational than current on-campus education," says Pritchard. "If you really want to experience distance learning, sit in the back of a large lecture hall." In contrast, he notes, "online learning can be easier to individualize, and it can be more interactive."

All the MOOC platforms have a long way to go, says Mike Sokolsky, Udacity cofounder and chief technology officer. For its part, Udacity is hiring new staff and tweaking its discussion forums to make them "feel much more collaborative" than the on-campus experience. "We're still very much experimenting with what MOOCs should be."

Jermey N. A. Matthews

Iowa lab gets critical materials research center

The DOE hub is set to be the largest R&D effort toward alleviating the global shortage of rare-earth metals.

The newly created Critical Materials Institute at the Ames Laboratory has the goals of expanding the supply and minimizing the use of rare-earth metals and other scarce elements. The CMI, whose participants include three other Department of Energy labs, US universities, and suppliers and end users of the elements, was selected from among proposals submitted in response to a 2012 DOE solicitation (see PHYSICS TODAY, July 2012, page 28).

Located at Iowa State University, the DOE-owned Ames Laboratory has a history of materials R&D and a particular specialty in rare-earth elements. The fifth of DOE's "energy innovation hubs," the CMI is scheduled to receive $120 million in federal funding over five years.

Rare-earth metals and other critical elements, such as germanium, tellurium, and platinum, are essential in a wide variety of electronic, energy, environmental, and military applications. In recent years consumption of the materials has grown rapidly along with demand for items such as flat-panel displays, hybrid vehicles, and clean-energy technologies. Supply from outside China has been slow to respond, due largely to the lack of investment and long lead times to bring new mines into production. The result is that China has gained a near-monopoly on the supply of rare-earth metals (see PHYSICS TODAY, May 2010, page 22).

In a 2011 report, DOE identified five rare-earth elements whose supply could affect clean-energy-technology deployment in the coming years: neodymium, dysprosium, terbium, europium, and yttrium.

Alex King, director of Ames and the new institute, says that one of the CMI's objectives is "to make mining a viable

AMES LABORATORY

The plasma torch in the Retech plasma furnace is one tool used in the materials preparation center at the Ames Laboratory to create ultrapure metal alloy samples, particularly of rare-earth metals.