

BY SALLY ATWOOD

THE INNOVATION BUBBLE

IT HAS BEEN 30 YEARS SINCE MIT LAST SAW SUCH A GROUNDSWELL OF EDUCATIONAL

The mission, should you decide to accept it: design an expedition to Mars to explore for signs of life, past or present. Travel to Mars has long intrigued engineers, scientists and the general public alike, so it came as no surprise to Kip Hodges, PhD '82, that in the summer of 2000, 85 first-year students accepted the challenge and applied for the 50 seats in his pilot course, Mission 2004.

"There's something incredibly sexy about the idea of life on Mars," says Christen Gray '04.

But the class is not just about traveling to Mars. It's an interdisciplinary course that does away with large lectures and small recitation sections and replaces them with teamwork and hands-on research. Hodges's class is just one of many experiments recently launched at MIT that explore innovative educational directions and integrate technology into the classroom. It's a growing trend in education, where the evidence is mounting that traditional lectures, problem sets, examinations and review sessions are less likely to promote conceptual understanding than a format that actively engages students by having them search for information and conduct experiments.

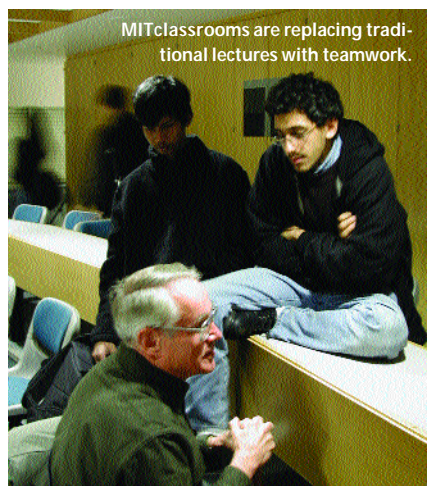
In the last two years, more than 30 proposals for active-learning and project-based curricula have received \$7.5 million from two funds. "The faculty has come out of the woodwork," says Provost Robert A. Brown. Hal Abelson, PhD '73, agrees. As one of three cochairs of the Council on Educational Technology,

which set and now oversees the strategic direction of educational innovation at the Institute—as well as the grant selection process—he sees far more proposals than the funds can support.

The funding comes from two sources—the d'Arbeloff Fund for Excellence in MIT Education, established through a gift from Brit, SM '61, and Alex d'Arbeloff '49, and iCampus, the Institute's alliance with Microsoft Research. Between the two funds, MIT will spend \$35 million over a five-year period to transform the classroom experience. Two highly visible proposals that fit comfortably into this initiative are the Mission classes and a studio-style version of introductory physics, taught in the new \$1.5 million Technology-Enabled Active-Learning (TEAL) classroom. Funds are also helping support institutional collaborations and an internal computer and library system to make it all work.

"YOU GET YOUR HANDS DIRTY"

Hodges was intrigued by the Mission class concept, which was one of the recommendations made by the Educational Design Project—a committee, which he chaired, that had been established in 1998 to review the freshman program and recommend improvements. When the committee's work was finished, Hodges sought funding to develop the course himself. The Mission class will run for five years and then be assessed to determine if it will become a permanent part of the first-year curriculum.



MIT classrooms are replacing traditional lectures with teamwork.



Jaime Peraire of aeronautics and astronautics simultaneously teaches students at MIT and in Singapore in a classroom filled with the latest technology.

INNOVATION, AND IT'S BEGINNING TO TRANSFORM THE CLASSROOM EXPERIENCE

Here's how it works. Each year, Hodges devises a problem that can be simply stated but is difficult to solve—if, indeed, it can be solved at all. Students are divided into groups of five and assigned various parts of the project. Each group includes two teaching fellows—students who act as guides—and at least one alumni mentor who works in a field related to the project. The students spend the semester gathering information and trying to reach a solution for their part of the project. At the end of the semester, each team presents its work to the class. The entire project is then put up on the Web.

Other than presenting some case studies to the class, Hodges does no lecturing. Instead, he guides students and encourages them to learn about their area through a coordinated team effort. "Most of the students have never had an experience where they are just told to do research," he says. "It's interesting to see how they change their approach to gathering information. They quickly become power users of the library, and they also find out quickly who the experts are and ask them questions."

Sheldon Buck '58, recently retired from Draper Labs, was one of 15 alumni mentors involved in Mission 2004—an experience he says he'd eagerly repeat if a future class touches on his area of expertise again. His job was to meet with students as often as possible and point them toward information or resources. Other alumni from outside the Boston area participated by e-mail or phone. Some students admit frustration at this style of teaching. "When we contacted our mentors, we were looking for direction," says JoHanna Przybylowski '05, "but they left things open ended"—which is exactly what Hodges hoped for.

Other students find this style suits them fine. "I've never encountered such intelligence and enthusiasm," says Christen

Gray '04 of her Mission 2004 class. So enthusiastic was she about her experience that she applied (successfully) to be a teaching fellow for Mission 2005 last fall. And the students in Mission 2005 (whose goal was to design a permanent, manned underwater research lab and to devise a research plan for its first six months of operation) didn't disappoint. "My group [robotics] was very enthusiastic. When the class presentation was done, they were still out taking tours and conducting interviews."

The final presentations of the two Mission classes amazed Hodges. "The depth and sophistication of what they've done is remarkable," he says. Justin Schmidt '01, now a graduate student and a teaching fellow for the classes, calls them "the most memorable classes in my 10 semesters. They are very interactive. You get your hands dirty."

FROM LECTURES TO LAPTOPS

Ask MIT students which freshman course they disliked the most, and chances are they'll say physics. For most students the two required physics courses—better known as 8.01 and 8.02—stand as difficult obstacles between them and their majors. John Belcher taught 8.02 in the large-lecture format for three years, and he found it frustrating. No matter how much effort he put into the lectures and demonstrations, huge numbers of students disengaged from the class. By the end of the semester, class attendance typically dropped to about 50 percent, and Belcher says he failed at least 15 percent of every class.

Belcher was aware of the studio-style active classes pioneered at the Rensselaer Polytechnic Institute and decided introductory physics was the perfect candidate for that style of teaching. MIT got behind the idea and allocated \$1.5 million to build the TEAL classroom, which was ready for the fall semes-

COURTESY OF RIP HODGES

FURNALDI/GRAY

ter. In the meantime, Belcher led a team of professors and programmers who spent nine months creating 15 experiments, writing software for them and integrating them into the syllabus. Last fall, the technology-enabled version of introductory electromagnetism—8.02T—was offered for the first time.

The beauty of the course lies in the integrated experiments, simulations and visualizations that students conduct or view on their laptops as soon as a concept is introduced by the professor. But it's more than just that. Instead of sitting in lecture chairs, students are assigned to tables and then organized into groups of three that remain in place for the semester. Each group has its own laptop. There's no podium on a dais for the professor, just a control center in the middle of the room from which information is projected onto whiteboards around the classroom.

Once a concept is introduced and the students are working on the laptops, the professor and teaching assistants wander around to the tables that they will supervise for the semester and answer questions. For the first time, 20 percent of the grade is based on group work done in class. And with the personal attention students receive, they remain engaged in the class despite its size. The departure from a conventional lecture format paid off. At the end of the semester, Belcher estimates, 85 percent of his students were still coming to class.

Stephanie Chang '03, who dropped 8.02 the first time she took it, applauds the new format. "It's hard to sit in a lecture and understand the material. In 8.02T, it was much easier to learn. We had hands-on labs and Java applets to help us understand. If you're doing a lab, you can't tune out."

Last fall, about 180 students took 8.02T. Over the next four years, the department plans to teach the two required introductory physics courses in this format to 90 percent of freshmen.

Another measure of success is faculty interest. "We have enough people [from other departments] who want to create these classes that there's pressure to create a second TEAL room next year," says Brown. "Tremendous resources went into [the classroom] because we believe long-term it has the possibility of changing the way we teach a whole bunch of major subjects."

REACHING OUT

Walk into 3-370 at seven in the morning or seven at night, and you're likely to hear MIT students talking and joking with fellow students 19,000 kilometers away at the National University of Singapore and at Singapore's Nanyang Technological University. For the last three years, MIT courses have been beamed to the other side of the world in the Institute's small but highly influential experiment in distance education. In an agreement with the Singapore government and the two universities, MIT provides most of the courses for five graduate programs. About

50 engineering and management faculty members teach the 150 Singapore students as well as the MIT students who enroll in the classes.

Although the Singapore-MIT Alliance is clearly a distance education initiative, Anthony Patera '78, SM '80, PhD '82, head of the academic program, says it's also a perfect example of how new instructional technology benefits MIT students on campus. "By virtue of having to think about being clear at a distance, I've become clearer here," Patera says. And that clarity seems to be paying off. In a recent survey of MIT students who have taken Singapore courses, most say they are better prepared and better presented than many MIT courses.

Perhaps the most talked-about collaboration on the MIT campus these days is a new educational program that has nothing to do with technology but steeply MIT students in the 800-year-old culture of the University of Cambridge in England. One of the key components of the new wide-ranging collaboration, known as the Cambridge-MIT Institute, is a junior year exchange program that will take 50 MIT students to the English university for a year and bring 50 British students to MIT.

For Gina Kim '02, who was one of nine students in the pilot group last year, the experience went well beyond academics. It was, she says, an "emphasis on life." And unlike MIT, with its unrelenting pressure, problem sets and exams, Cambridge treats learning as more of an independent venture. "You have to be really motivated," Kim says.

Kim had time to take in many plays and concerts in London, traveled on the Continent and played in several student music ensembles. "What I learned outside academics will prepare me for life," she says. But Kim also learned another lesson: "I learned how I learn, and I know I need structure. I do better under the MIT system." So much better that Kim has decided to enter a master's-degree program at MIT next fall.

NEW TOOLS

All these innovative teaching technologies spurred the development of two basic resources. One was a computing platform that could handle all the needs of the faculty. The other was a way to store the digital output being created. And since nothing available on the market supported everything MIT needed, the Institute had to devise its own solutions through the Open Knowledge Initiative.

"The challenge was to build an architecture to support a variety of educational applications that is sustainable over time," says Vijay Kumar, director of academic computing.

Because other institutions were facing the same problem, interest from the higher-education community was immediate. Soon Stanford University joined the project as a key partner, and eventually five other universities—including Cambridge—and a



MIT juniors spent last year at the University of Cambridge in the pilot year of a student exchange program with the British university.

college became collaborators. This presented another challenge, according to Kumar. "We want to make sure the tools that are built for one institution or department can be used in another context without too much retooling." This spring, the Open Knowledge Initiative has been rolling out the new platform.

While Kumar worried about the computer architecture to support the Institute's educational innovations, Ann Wolpert, director of libraries at MIT, was concerned about how to store all of the new digital materials being generated. The answer: DSpace, an institutional archive that presents the same elements as a traditional library, only in digital format. Permanent URL addresses for Web-based materials will enable faculty to point colleagues and students to the information from any place on campus, for differing purposes and for an indefinite period of time. DSpace provides varying layers of access so that users outside MIT will be able to view materials at whatever level is appropriate.

"MIT is way ahead of the curve," says Wolpert. "Our peer institutions are just now trying to figure out how to build a bin to hold this digital output. MIT already has a digital file cabinet."

SUSTAINING INNOVATION

With more than 30 projects funded, there's no shortage of new educational approaches to consider. "The burden we have now," says Brown, "is that innovation has to be sustainable."

Sustainability has two components. First, says Abelson, a department has to be able to support a project once funding from the d'Arbeloff Fund and iCampus is exhausted; or alternatively, funds from within the Institute or from an outside source must be identified to run the programs. For dean of undergraduate education Robert P. Redwine, who cochairs the Council on Educational Technology with Abelson and Brown,

sustainability means that "when people who are pushing it at the beginning burn out or move on, the project becomes a regular part of the way of doing business."

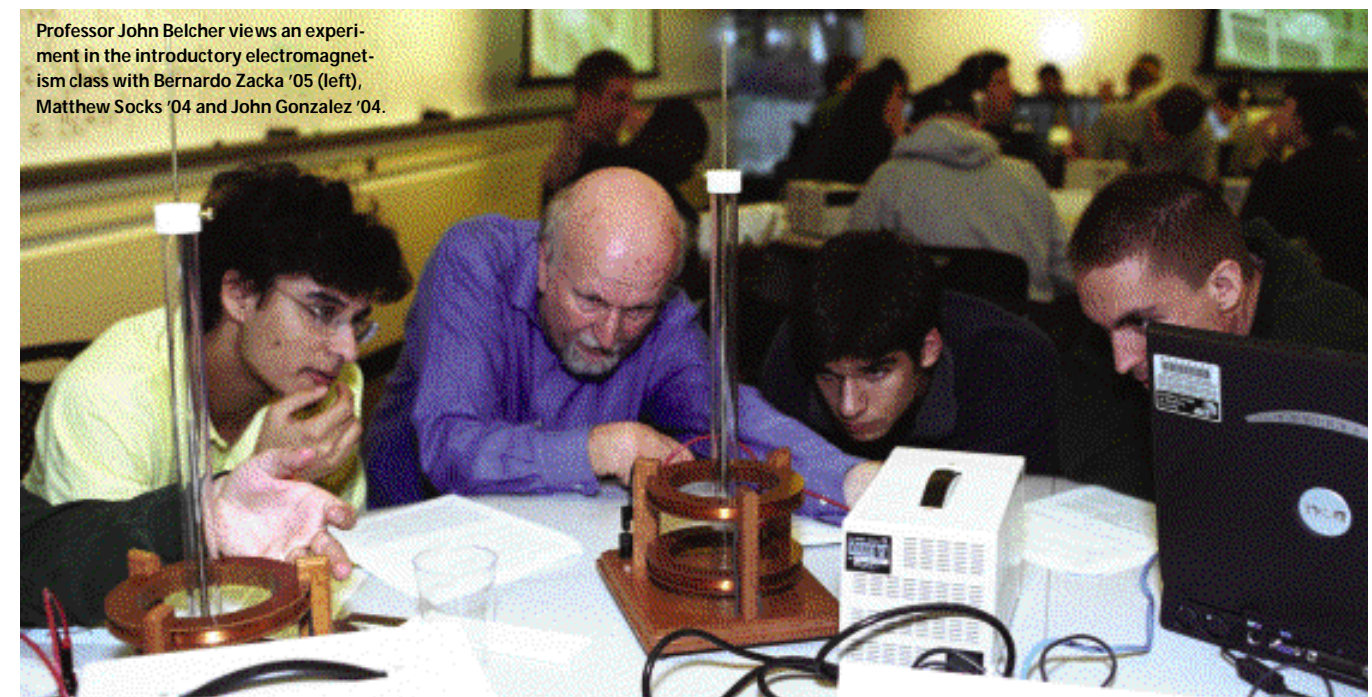
But even if a project is sustainable, it also has to prove its educational value. An assessment component is required of all proposals, and the Teaching and Learning Laboratory has been charged with "overseeing, aiding and in some cases implementing the assessment efforts of many of the new educational initiatives that have begun at the Institute in the last several years," Lori Breslow, director of the lab, wrote in the winter issue of the MIT Faculty Newsletter.

"We've put real resources into assessment," says Brown. "You can't sustain everything, so you have to ask, does this actually work? Does it lead to educational value? We have to make hard decisions."

The subcommittee charged with doling out the funds has plenty of difficult decisions to make, too. "I think of the iCampus and d'Arbeloff people who are managing the grants as venture capitalists," says Brown. "They want to spark innovation, and they've got to put major resources behind things that have large impact. Will they put millions into something they don't think is sustainable long-term and has large impact? The answer is no."

Projects that have yet to prove their impact can turn to smaller pots of money targeted for innovation. Alumni funds established by the Classes of '51, '55 and '72 have provided seed grants for many projects. By the time the d'Arbeloff and iCampus funds came along, some of these projects had evolved to the point that they needed serious money, and they got it.

Innovation unleashes energy and creates excitement. With the broad scope of initiatives on campus, MIT is moving into rare air. But in the end, d'Arbeloff says, "the challenge will be, to what extent are we going to make these changes permanent?"



Professor John Belcher views an experiment in the introductory electromagnetism class with Bernardo Zacka '05 (left), Matthew Socks '04 and John Gonzalez '04.

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