Large lectures and an ultracompetitive culture are giving way to hands-on learning, problem-solving and teamwork

By Margaret Loftus

Like many students who excel in high school math, Victoria Messerschmidt gravitated toward engineering in college on the advice of her guidance counselor, though she wasn’t entirely sure what engineers do or what studying to be one would entail. “I was afraid it would be all giant lecture halls of 500 students,” she remembers, “and then it would dwindle to all the people that survived.”

Messerschmidt’s fears were not exactly unfounded. The “chalk and talk” style of teaching has long been entrenched in engineering schools, and generations of freshmen have absorbed the stern warning that most of them won’t make it to graduation day. But after years of soul-searching over a 50 percent dropout rate and a shrinking supply of homegrown engineers, many of the schools that produce them are changing their ways. At Purdue University School of Engineering, where she is now a sophomore majoring in biomedical engineering, Messerschmidt found classrooms configured for group collaboration and wired for high-tech problem-solving instead of cavernous lecture halls, and a curriculum packed with hands-on learning geared toward keeping students engaged rather than weeding them out. And forget memorization for multiple-choice exams. Messerschmidt’s final in Intro to Design, for example, tasked her and her teammates with creating a light sensor that detects envelopes in a student’s mailbox and triggers notification by email. “It was putting into context what you’re going to be doing for your job,” she says. In short, Messerschmidt quickly got a sense of what an engineer’s job entails because she was doing it.

The shift to experiential and student-centered learning is crucial to attracting and retaining more engineering students, experts say, and especially women and underrepresented minorities, who make up just 18 percent and 13 percent, respectively, of grads. Given the need in the early years to master theories and principles, “one of the problems has been that it’s taking students too long to get to the real-world stuff, the fun stuff,” says Randy Atkins, the director of the National Academy of Engineering’s Grand Challenges for Engineering project – an initiative that has...
identified top engineering challenges of the 21st century, from making solar energy economical to preventing nuclear terror, and promotes finding solutions. "We find that women and minorities want to go into careers that help people, but maybe they need to get the picture a little bit better. They need to know that if you create the new generation of MRI machine, you're going to affect the lives of more people than a doctor."

To that end, students are now rolling up their sleeves on Day One. At Harvey Mudd College in Claremont, Calif., for example, where nearly every engineering course has a project-based component, the first task for freshmen in Introduction to Engineering Design is to take a pencil sharpener apart and write a report on it. "These are 18-year-old kids who have probably never done any engineering before they come to college," says Ziyad Duron, the chair of the engineering department. He quizzes incoming students on their practical background: Have they ever changed the oil in their car? "Most say no. The vast majority of students are growing up behind a keyboard. So the course is really designed to work them out of that a little bit." The class culminates in a service project; last year, teams designed a lift for physically challenged students at a local school.

Their second year, in Experimental Engineering, Harvey Mudd students conduct a series of experiments that include building a small rocket and launching it in the desert. They gather data in-flight, then analyze and present it. The point is to tie theory to real, practical applications, says Duron.

"The earlier we expose them to project-based learning, the earlier we break down their barriers, their fears over hardware and software, and the clearer their learning experience is." As a result, he says, students today see complicated theoretical topics in a way students even 10 years ago could not.

Increasingly, the team projects draw students from multiple engineering disciplines and even from outside the engineering school. At Rowan University College of Engineering in Glassboro, N.J., students from each of its programs – chemical, civil and environmental, electrical and computer, and mechanical engineering – join forces in "clinics" that span all eight semesters to master multidisciplinary teamwork and communication skills and work on projects for
real customers, from designing power grids to creating software protection programs. And last summer, Rose-Hulman Institute of Technology in Terre Haute, Ind., began piloting an intensive 12-credit research project inspired by the NAE's Grand Challenges that tasked multidisciplinary teams with creating affordable and accessible solar energy options for Kenya and other developing countries. In fact, more than a dozen engineering schools, including Duke University, the Franklin W. Olin College of Engineering outside Boston and the University of Southern California, have adopted coursework and extracurricular activities such as service projects aimed at solving the Grand Challenges.

Some schools are putting these projects in spiffy new spaces dedicated solely to labwork and collaboration. This fall, the University of Delaware will debut a 194,000-square-foot Interdisciplinary Science and Engineering Laboratory, in which eight labs adjoin four small classrooms with furniture on wheels that can easily be configured for work in teams. Purdue introduced the i2i Learning Laboratory in 2006, a cluster of seven spaces each focused on a step of the design process. A studio room, for instance, is appointed with tablet PCs, video projectors and data-acquisition equipment and is lined with wall-to-ceiling whiteboard, so groups of first-year students can gather information and hash out their ideas.

The technology made a big impression on Claire Lang, now a mechanical engineering sophomore at Purdue. She especially appreciated her freshmen Computer Graphic Analysis course, in which she designed components using a 3-D modeling system. “Learning lab work really stood out for me,” she says. “At Purdue, they throw you in. My professor didn’t treat me as a freshman who didn’t know anything. He said, ‘We’re now doing engineering.’”

While lectures are by no means obsolete, many programs have reshaped them and put them online to better suit the learning styles of today’s students and to free up class time for more active learning. Inspired by the “flipped classroom” movement gaining momentum in other fields, Purdue last year introduced a series of 15-minute online learning modules for the two-semester course Transforming Ideas to Innovation. The modules allow students to prep on various topics ahead of time so they can spend their class time on activities supported by the professor, teaching assistants and peer assistants, rather than dozing through a lecture. “When we’d give students reading, they would never do it. They’d come to class having no idea what we were going to do. By moving the lecture outside of the classroom, students are more on topic and more engaged,” says Eric Holloway, the managing director of the School of Engineering Education, which oversees Purdue’s first-year engineering program.

Even traditional weed-out classes, such as calculus, have become more student-friendly. In a method developed by science education researchers at North Carolina State University, educators at Clemson University in South Carolina have inverted the way the class is typically taught. Instead of the instructor having the floor — and ostensibly the students’ attention — for most of the class, students sit at round tables wired for laptop use and work on problems together, with input from the instructor. The approach empowers all the students, instead of just a few, says Lisa Benson, associate professor of engineering and science education. The first year, just 5 percent of students taught multivariate calculus this way earned a D, failed, or withdrew, compared to 30 percent in lecture-based calculus sections.

Other student-centered programs have reported promising outcomes as well. Purdue, Rowan and Harvey Mudd now boast freshman retention rates close to or above 90 percent. Women make up more than half of the students engaged in the Grand Challenges program at the dozen institutions that have implemented it. And Harvey Mudd is on track to graduate a majority female class of engineers in 2014.

“We want students to get excited about engineering,” says Holloway, who has clear memories of being a freshman at Purdue 25 years ago and taking the Intro to Engineering “seminar” alongside 450 other students. The course, he recalls, was nicknamed Sleep 100. ⋅