the new school

Educators change tactics to train the best engineers

BY WILLIAM INMAN

American universities have long been the proving ground for the world's crop of engineers. But emboldened countries like China and India, hungry for engineers to power their expanding research sectors and economies onto the global marketplace, have strengthened their higher education systems to ensure that their brightest stay home. And in the new tech-driven arena of engineering, American university graduates are rapidly becoming small fish in an ocean of engineers, an ocean in which many can and will do the same job for much less.

Considering the growing concern of outsourced engineering jobs and the impending decline of America's technological dominance, an onus falls upon American universities to continue to attract and educate the future leaders of innovation.

But there are myriad new obstacles. According to research by the National Academy of Engineering, the United States is producing only 7 percent of the world's engineers. And that total is becoming less diverse over time. The percentages of women and African-Americans enrolling in engineering programs are at a 14-year low, for example. Visa restrictions enacted after the Sept. 11 attacks have made it increasingly difficult for international students to study in the United States, further homogenizing the pool.

These factors are not only problematic because of "a narrow design perspective," but also because "failing to recruit from large segments of the population means the number of new engineers we produce falls well short of our potential," says Domenico Grasso, Ph.D., dean of engineering and mathematical sciences at the University of Vermont.

"This is a very interesting challenge that engineering as a community is facing," adds S. David Wu, Ph.D., dean of the P.C. Rossin College of Engineering and Applied Science at Lehigh University.

"Students are competing with a much larger number of competitors — there are 10 times the number of them across the planet and companies know that — and in a lot of cases their wage is a fraction of what it costs in the United States [to do the same job]," he says.

Indeed, the numbers are staggering. China will graduate around 600,000 engineers this year while India will graduate close to 350,000. By contrast, the United States will graduate about 70,000.

"American engineers are at relative parity with their foreign-born counterparts, are more expensive, and offer no competitive advantage," Grasso says.

Wu boils it down further: "The question is, How do you make the student who graduated from a U.S. engineering program have that additional edge that would be worth the additional investment for a company?"

The answer is a slippery one, but Wu, Grasso, and other engineering educators say a revamped, agile, multidisciplinary, more globally-oriented approach to the traditional engineering education is the sea change needed to ready American graduates for the challenges of the future.

New perspectives

Wu proposes a wholesale change in the approach of engineering education, suggesting that it become the "the liberal education for the 21st century."

Appointed to dean of the college in December 2004, Wu has been instrumental in developing multidisciplinary programs at the undergraduate and graduate level at Lehigh, a private university in Bethlehem, Pa. Wu, who has been on the faculty since 1987, formerly served as chair of the industrial and systems engineering department.

"You think of a liberal education as one where you learn the fundamentals [to] deal with issues that we face in society," he says. "In order to sustain the competitive position of engineering in the United States, we basically need to have some really careful and strategic thinking going to how we should reconfigure our engineering education in a way that we will remain competitive and keep our leadership position."

During his six years as chair of the ISE department, Wu reached out to other colleges and departments at Lehigh as well as other universities to help establish innovative academic programs. As dean, he plans to broaden further the engineering curriculum — a strategic goal he has set for the college. A more diverse curriculum, he says, will prepare students to become multi-faceted technical coordinators and global team leaders.

A cross-disciplinary program Wu developed has met with considerable success at Lehigh. The undergraduate program in integrated business and engineering (IBE) is a collaboration between the College of Engineering and the College of Business and Economics.

Students enrolled in the IBE can major in engineering or business, but the core classes are a mix of both disciplines.

"This is a very tough curriculum because the student will be taking what a typical engineering student would take plus the core of classes from business," Wu said. "It's an honors program, and we're able to recruit some of the best students. So they are highly motivated and they really excel.

"You can think of this as an extension of IE but even broader. The whole idea of combining the engineering quantitative skills and analytical skills with knowledge of business is very powerful," he said.

S. David Wu, Ph.D., dean of the P.C. Rossin College of Engineering and Applied Science at Lehigh University

Students are also able to study for a fifth year and receive a dual degree in engineering.

"They really use the engineering education to go into a broader career path. They may go into entrepreneurship or they may work in a traditional technical area, but they have much broader exposure; therefore, they would assume functions that are not traditionally for engineers," he said. "Because of the caliber of students we get, many of them do decide to go on to graduate school, and in that case, they would either go deeper in the engineering discipline or pursue their business degree."

Joseph Hartman, Ph.D., who took over for Wu as chair of the ISE department at Lehigh, says the cross-disciplinary coursework has a real-world feel.

"We talk about problem solving, but we also design products," he said. "Because when you get out of here, you're going to be thrown onto teams with engineers, someone from marketing, someone with an arts and science background because they bring a different perspective to the table. And I think we're trying to get a piece of that now and I think that's important."

It's not that engineering instruction needs to change, Hartman says, but that engineering students should be exposed to its applications.

"What we teach in engineering generally doesn't change: fundamentals, how to solve problems, how to model, how to simulate, how to analyze the situation. But what we don't always teach is the context," Hartman observed. "What we need to do is give them more opportunities to learn the context of their applications. They may have to go to the business school to learn how that would work in a financial setting; they may have to go to earth and environmental science to learn the environmental impact of some decision. There's a realization out there that we bring a tool set to a variety of occupations in society, not the one's we traditionally call engineering."

Along with diversifying the curriculum, Wu says it is equally important to deepen the tradition of excellence the United States holds in engineering and innovation. And since this competitive advantage leads to new industries and higher-paying jobs, this ability to stay atop the research areas in which the United States has an edge is paramount. Wu says this is especially important in the emerging fields of biotechnology and nanotechnology.

Wu is also quick to point out that the many emerging areas of engineering, such as bio-, nano-, opto-, and information technology, are multidisciplinary.

The global laboratory

Another multidisciplinary program Wu developed is a partnership with the Wharton School of Business called the Integrative Graduate Education and Research Training Program (IGERT). The program is a joint doctorate with a focus on global logistics. Wu and Patrick Harker, Ph.D., now dean of the University of Pennsylvania's prestigious business school, worked together to win a major grant from the National Science Foundation and design the program.

"Traditional doctorate programs tend to be very narrow, where a student spends a lot of time on a specialized topic," Wu said. "This is a much broader set of training for them."

VALUED VISAS

In his speech before the subcommittee on Immigration, Border Security, and Claims Committee on the Judiciary of the U.S. House of Representatives, William A. Wulf, Ph.D., president of the National Academy of Engineering, stressed the importance of foreign-born doctoral degree holders in science and engineering to American national security. The crux of Wulf's speech, given just four days after the fourth anniversary of Sept. 11, was the relationship between technological and economic prowess and national security.

Many others in business and academia worry that visa restrictions enacted after Sept. 11 for international students, scholars, scientists, and engineers have created a misperception that these visitors are no longer welcome here.

Wulf, a professor of computer science at the University of Virginia, a former member of the Air Force Science Advisory Board, and an advisor to the Department of Defense, noted that in the past many of America's scientific leaders were European. He invoked names such as Einstein, Fermi, and von Neumann, and said that today's names that contribute to American science and engineering are those from countries around the world.

Wulf said that the NAE estimates that the current percentage of foreign-born Ph.D. engineers is more than 50 percent, and he added that one-fourth of the engineering faculty members at U.S. universities were born abroad.

Earlier this year, the National Academies (the National Academy of Science, the National Academy of Engineering, the Institute of Medicine, and the National Research Council) made several recommendations to the U.S. government regarding the safeguards put in place in the nation's visa system. They include:

- Extend the validity of Visas Mantis security clearances for international scholars and scientists from the current two-year limit to the duration of their academic appointment.
- Allow international students, scholars, scientists, and engineers to renew their visas in the United States.
- Renegotiate visa reciprocity agreements between the United States and key sending countries, such as China, to extend the duration of visas each country grants citizens of the other and to permit multiple entries on a single visa.
- Amend inflexible requirements that lead to frequent student visa denials.
- Develop a national strategy to promote academic and scientific exchange and to encourage international students, scholars, scientists, and engineers to pursue higher education and research opportunities in the United States.
- The federal government should not require that export licenses be obtained for international scientists and engineers to use equipment required to conduct unclassified, fundamental research in the United States.

Source: The National Academies

The IGERT program, founded in 1999, provides fellows with a tuition waiver, a stipend, and educational expenses to cover an industrial internship in the United States and an academic internship overseas. Taken their second year, the four- to six-month international internship sends the students to one of 15 institutions across the globe.

Wu talks with his engineering students.

"The idea is to learn how to operate in a professional level with a group of people from a different culture in a different way," Wu says. "It has a pretty profound impact on them.

"To get the students out in global environment and have a firsthand understanding of how that would affect the future of the economy here in the United States and globally, nothing can really substitute that kind of firsthand exposure," he said. "So that is very much a part of our educational strategy to incorporate an international perspective."

John English, Ph.D., head of the industrial engineering department at the University of Arkansas, says developing opportunities for study abroad is an emerging trend in industrial engineering departments.

"We've had a growing number of undergrads pursue opportunities in trying to get study-abroad, and we've had some endowments given where we're helping to facilitate that through scholarships," he said "I think that we'll start seeing students go overseas to study, and honors colleges are going to be supportive of this. I really do think there is going to be a trend."

To prepare the next generation of American engineers for the future, educators must be able to predict and respond to the same challenges their pupils will face.

"We have to prove our students to be technically the best, and so we need to stay on the edge of technology and not let our curriculum die on the vine," English said. "We have to be able to reinvent ourselves."

Wu puts it more simply: "We've got to train the best engineers."