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A Look at the State of Engineering Education Worldwide

Top IEEE educators share their views about diversity and declining enrollment

By KATHY PRETZ (/author/pretz-kathy) 1 September 2016

The need for qualified engineers has never been greater. Engineering schools are increasingly under pressure to build young people's job readiness as the labor market demands better-skilled workers.

Illustration: Daniel Hertzberg

There are other challenges as well. At some schools, the student body is older and more culturally, ethnically, and economically diverse. Others find that enrollment in science, technology, engineering, and math (STEM) disciplines at the high school level is decreasing, so fewer students are applying. The amount of material that's required to be covered continues to increase.

These are just some of the issues that leaders of engineering schools shared with *The Institute*, along with what they're doing to address them.

DIVERSITY

Nearly all the educators noted that diversity is a concern as well as an opportunity. But the term *diversity* can mean something different to each one.

A student body composed of more adults and people with different ethnicities and cultures is what it means for IEEE Fellow S.K. Ramesh, dean of the College of Engineering and Computer Science at California State University, Northridge. He's also vice president of **IEEE Educational Activities (https://www.ieee.org/education_careers/education/eab/eab.html)**.

"Twenty-some years ago, we did not have the sort of diversity in the student body that we're seeing today," Ramesh says. "We are seeing many more first-generation students and nontraditional students who are balancing life and work responsibilities as they pursue their degrees.

"One thing we must do to attract traditionally underserved populations is to look at the way we're teaching our courses to see whether they're culturally sensitive and they're relevant to students from diverse backgrounds and cultures."

For instance, one of the programs he's involved with, **TIDES (Teaching to Increase Diversity and Equity in STEM) (http://www.aacu.org/tides)**, incorporates culturally relevant music references into core introductory programming courses, improving student retention and success. The TIDES modules are available at no charge to anyone around the world.

"We need to address the challenges of an increasingly diverse student body by ensuring that faculty are aware of the different cultural backgrounds and life experiences of their students and are inclusive and empathetic to diverse learning styles," he says. "What works in North America may not work in Southeast Asia or Latin America." By adopting culturally sensitive teaching methods, he adds, faculty can help engineering become more relevant and meaningful for students from different cultures and backgrounds.

To 2006 IEEE President and Fellow Leah Jamieson, dean of engineering at Purdue University, in West Lafayette, Ind., diversity means including more women in engineering programs. About 19 percent of students in U.S. engineering programs are women, Jamieson says, but she proudly points out that for the 2015 fall semester, women made up 29 percent of Purdue's first-year engineering class and about one-quarter of all its engineering students.

"We're thrilled that we're above the national average," she says, "but that's because we work at it like crazy.

"A wealth of research shows that innovation and diversity are intimately connected. If you have people with different backgrounds, different perspectives, different life experiences, and different ways of thinking about a solution to a difficult problem, the diverse team is going to come up with more creative solutions."

In South Africa, IEEE Senior Member Saurabh Sinha serves students from diverse socioeconomic backgrounds and with varying degrees of educational preparedness. Sinha is the executive dean of the faculty of engineering and the built environment at the University of Johannesburg. He is also a past vice president of IEEE Educational Activities.

"South Africa's higher education institutions inherited generational challenges brought about by apartheid and have to cope with a 'two-tiered' national economy: one that is first-world and the other in the emerging world," he says.

Because of historical segregation, he says, "universities receive students with exceptional potential—bearing in mind that very few have access to universities—but with wide-ranging levels of preparedness in STEM subjects." His university has addressed this by developing varied first-year programs, including extended programs.

"Among others, we offer students who can't cope with these educational differences a bridge year," he says. They take additional courses in math and science and are gradually given a heavier workload than they might be used to, thus preparing them for what they'll find in the university. "The first-year experience is essential for their preparation," he says.

DECLINING ENROLLMENT

Universities in Hong Kong are having a difficult time attracting students to engineering, especially electronics engineering, according to IEEE Senior Member Hon Tsang, who chairs the department of electronics engineering at the Chinese University of Hong Kong. He's also a member of *The Institute*'s editorial advisory board.

"Since about 2012 we've seen a sharp decline among high school students who study calculus and physics," Tsang says. That's when the country's high school system went from one based on a British model (which required seven years of study) to one modeled after mainland China's (six years).

"Because engineering relies heavily on math and science, we've had rather disappointing enrollment numbers in electrical engineering in the last three or four years," Tsang says. He also attributes the drop to misconceptions about employment opportunities and salaries for engineers.

"The impression is there are really no high-tech employers in Hong Kong and, therefore, a lack of job opportunities," he says. But engineers are needed, he notes, in banking, logistics, insurance, and other service industries. Because demand outstrips supply, Tsang says, all his school's engineering graduates are employed within a year.

"That's good news for our graduates," he says, "but bad news for industry, because we're not supplying the number of engineers they need."

Entry-level salaries for engineers are lower than those for doctors and lawyers, he concedes, but after two or three years, engineers' salaries increase rapidly.

Hong Kong's educators and industries have begun to work on ways to address the drop in enrollment, he says. One suggestion is to improve the public's awareness of the importance of science and engineering and the career opportunities that exist.

Jamieson agrees that the right message is important. She points to the ***Changing the Conversation (http://www.nae.edu/Publications/Bridge/51063/51069.aspx)*** report published in 2008 by the U.S. National Academy of Engineering.

"I felt it was trying to shake us by saying, 'Stop talking about the skills you need and about how you have to love math and science and start talking about the fact that engineers make a difference in the world,'" she says. "The academy did a really nice study of public perceptions, and we [at Purdue] took it to heart. We changed how we talk to prospective students."

In South Africa, a student's first-year university experience involves tutors and mentors as well as classes in time management, confidence building, and advanced study skills. "With this assistance, the aim is to reduce student drop-out rates," Sinha says.

Ramesh reports that California ranks last out of the 10 U.S. states with the largest Latino student populations for the percentage of Latinos earning bachelor's degrees in engineering and computer science. That's according to the **Campaign for College Opportunity (http://collegecampaign.org/)**, a nonprofit advocacy group focused on higher education. **Excelencia in Education (http://www.edexcelencia.org/)**, a not-for-profit advocacy group that hopes to accelerate Latino student success in higher education, has partnered with the Campaign for College Opportunity to help California's Latino students. The state has a 10 percent gap between Latinos and whites when it comes to graduation rates, the group says.

"Clearly we have a big gap in achievement," Ramesh says, "and we are working to turn things around with cohort-based programs to improve student support, mentoring, and tutoring."

One way to keep students engaged and continuing their engineering studies, Ramesh and Sinha agree, is to involve them in hands-on projects, like those found in **EPICS (Engineering Projects in Community Service) in IEEE (http://epics.ieee.org/about/)**. Rather than working only on problems posed in the classroom, high school students involved with EPICS are matched with IEEE volunteers and student members to collaborate with community organizations on engineering-related projects. Jamieson started EPICS with Purdue colleagues in 1995 as a way to address feedback from industry at the time that engineering programs were not equipping students with essential professional skills.

"These types of community service programs inspire the next generation of students and help them understand why engineering is so important," Ramesh says. "At the end of the day, how are engineers using their knowledge and their technical backgrounds to help the community at large?"

CAN'T TEACH IT ALL

The educators agree that the traditional four-year bachelor's degree program does not provide enough time to cover the fundamentals and provide training in specialized areas.

The first semester is spent teaching fundamentals and, in Hong Kong, Tsang notes, covering basic science and math concepts that used to be taught in high school. "We're finding it extremely tough to teach everything we think we should within the usual four years," he says.

Schools are under pressure from industry, Jamieson says, to teach nontechnical skills such as teamwork, verbal and written communication, ethics, and how to combine technical and business perspectives. "No one wants to take away any of the technical skills or stop teaching foundational math and science courses," she says, "but the broad set of skills expected of the graduate continues to increase.

"We need to recognize that when students graduate they're not going to know everything, and the education they get at a university must be a really effective springboard to learning throughout their careers."

Schools should stick to teaching the fundamentals, Ramesh says, because there are many subjects that universities can't possibly teach given their time constraints and resources.

"Students need academic rigor," he says. "Ultimately, when students go into industry or graduate school, they're going to be using the fundamental skills learned as an undergrad." It's up to individuals to take ownership of their careers and stay technically current, he adds.

Sinha notes that the University of Johannesburg is experimenting with new methods focused on the learners, not just the teachers. That includes student-centered education, whereby the student takes the lead in explaining a topic and the lecturer is the facilitator. There's also so-called active learning or learning by doing.

"This approach takes the learning of fundamentals and applies it to practical problems," Sinha says. "It links advanced mathematics to the reality of engineering to get learners excited about the importance of STEM."

Engineering schools need a more systematic, rigorous, and scholarly way of continuing to improve, Jamieson says, because "there are always going to be challenges, and the pace of change is always going to be fast."

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