Guest Editorial
K–12: Engineering's New Frontier

CELL PHONES, the Internet, MRI, GPS, HDTV. Each of these great engineering innovations were designed, created, and brought into wide use over the last three decades, and by certain accounts, most of the new technologies that we use every day in our common lives have been designed and built over the last 30 years. Clearly, engineering has had a great run—and the good news is that there does not seem to be any end in sight.

However, you would not recognize their success by looking at the historical engineering enrollments at U.S. universities. During engineering's greatest period of creativity and growth, schools and colleges of engineering across the U.S. have lost nearly 25% of their undergraduate student population—from a high of nearly 450 000 students in 1982 to just over 350 000 in the year 2000.

Not every discipline within engineering has suffered equally—my own field of electrical engineering has been hit as hard as any. In 1987, departments of electrical engineering nationwide graduated almost 25 000 undergraduate students annually. By the year 2000, this number had fallen by almost 50%, to only 12 600. While some of this decrease can be attributed to the rise of computer engineering degrees, it is nevertheless perplexing that this core degree of modern high-tech engineering has been undergoing such a precipitous decline—with no apparent end in sight.

Unfortunately, these gross numbers do not tell the full story. As a field, we continue to struggle to increase the diversity of U.S. students pursuing and completing engineering degrees. Women, engineering's largest underrepresented group, have made only modest gains over the last 30 years. In 1972, before the Advent of Title IX—the federal legislation enacted to increase gender diversity on college campuses—less than 4% of engineering students were female. (As a comparison, in 1972, 9% of medical students and 7% of law students were female.)

During the past three decades, both medical and law schools have been able to reach gender parity in their entering classes without a loss in student quality and without a loss in the sizes of their graduating classes. Sadly, engineering still lags far behind both fields, with women representing approximately 20% of our total engineering graduates and less than 15% of electrical engineering graduates—during a time when the number of women going to college has risen sharply, from 5.9 million in 1980 to 8.6 million in 2002. The numbers for other traditional underrepresented groups in the U.S.—Hispanics and African Americans—are no better. In any given year, approximately 800 000 minority students graduate from high school. However, in 2000, only 7 200 of these students graduated from a university with an engineering degree.

To appreciate fully these numbers, it is appropriate for us to consider the broader reach and impact of our discipline. The best place to begin is with higher education's baseline student population—high school graduates. There are nearly 4 million U.S. high schools students graduating each year. Unfortunately, less than 2% of these students will ever obtain an engineering degree from a U.S. engineering school. And, from a diversity perspective, only two thirds of 1% of the approximately 2 million female high school graduates will earn engineering degrees, while only nine tenths of 1% of our 800 000 minority high school graduates will earn engineering degrees.

These percentages are shockingly low, given the prospective for long-term growth in the U.S. and world's engineering and high-tech economies. An engineering degree is not only a ticket to one of the highest paid professions, it also affords the graduate with a unique opportunity to work in a dynamic field that can have a direct impact on our world.

These numbers tell us just as much about ourselves—engineering educators—as they tell us about our prospective students. Although engineering has completely changed these young students' world, it has unfortunately become somehow irrelevant, or even out of reach, to them. It is a sad reality that other young students from across the globe are clamoring to be admitted into engineering schools, yet U.S. students, who spend much of their day talking on cell phones created by engineers, driving cars designed by engineers, and surfing the Internet made faster and more engaging by engineers, are passing us by for other opportunities.

Fortunately, these facts are not escaping the leaders of many of the U.S. engineering schools and nonprofit organizations. The National Academy of Engineering, the American Society for Engineering Education, and organizations such as the Society of Women Engineers (SWE), the National Society of Black Engineers (NSBE), the Women in Engineering Programs and Advocates Network (WEPAN), and the Society of Hispanic Professional Engineers (SHPE), as well as many professional societies, such as the IEEE, are concerned and, more important, acting to address this problem.

While each of these organizations has its own set of strong initiatives to address the lack of interest and preparedness of our high school students in engineering, I would like to take this opportunity to describe one program, named the Infinity Project, which I believe has a very strong chance of changing the landscape in engineering education—particularly in the precollege arena.

The Infinity Project began more than three years ago as a collaborative effort led by national experts in engineering education and industry, together with precollege educators and leaders, all with the clear purpose of creating a complete high-tech engineering curriculum for high school students. Today, the program

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is being directed from the new, federally funded Institute for Engineering Education at SMU in Dallas, TX.

From the beginning, the overriding purpose of the Infinity Project was to ensure that every high school student has the opportunity to be exposed to the best content at the heart of modern engineering in a substantive, engaging, and hands-on way. The resulting curriculum created by this team was organized around the model used in all courses in high schools—thus making engineering a "regular," or normal, part of a student's high school experience.

In the very short existence of the Infinity Project, we have been fortunate to have worked with schools in 14 U.S. states—from Hawaii to Alabama to Connecticut. Surveys with our partners have shown that the key ingredient for our rapid success is that the program was created as a complete, low-cost, turnkey solution that yields high results.

The Infinity Project supplies schools and teachers with several benefits:

1) a comprehensive year-long curriculum that emphasizes the math and science behind engineering design,
2) a complete professional development program for teachers with little or no experience in technology and engineering,
3) state-of-the-art classroom technology that puts the power of modern digital technologies in the hands of creative young minds.

The program is expanding today by partnering with colleges of engineering to support the deployment of engineering curricula in school districts and communities that serve as historic feeders to their programs, and the Infinity Project is looking to expand its reach with additional university partners over the coming years.

Happily, the demand for the program has grown steadily over time—demonstrating that a wide variety of schools today see a real need to complement their existing curricula in traditional math and science with modern engineering.

Let me give you just a few data points that demonstrate the impact of a high school engineering course on creating a well-prepared and diverse pool of potential engineers. More than 50% of all students who have taken the course have been young women, and more than 60% of students have been from underrepresented communities. In addition, 65% of the students completing the course report a very strong interest in becoming an engineer. Finally, and possibly the most telling point, is that nearly all students who have taken the Infinity Project's engineering course have said that they would "recommend it to a friend."

The world is changing, becoming more reliant on engineering and engineers. Because of this change, it is increasingly important that young students be exposed to modern engineering and technology in a systematic way. Clearly, a variety of techniques address this important need, so why did the Infinity Project decide to follow the path of creating a complete high school engineering course? There are several reasons.

Exposure. How do we expect students to know that they want to be engineers if they have never been exposed to engineering? Surveys show that children of engineers have a much higher likelihood of becoming engineers than those students without any personal connection to the field. Therefore, to create a larger and more diverse pool of potential engineers, we must expose as many students as possible to engineering through traditional educational programs, such as an actual engineering course. Long existing afternoon or summer programs have shown some success, but they unfortunately deal primarily with the current pool of self-selected students who already have a strong interest in engineering.

Motivation. Math teachers are constantly having to answer the age-old question "When am I ever going to use this?" Those of us in the field know that engineering is one of the most relevant users of mathematics—used not just to solve abstract problems, but to solve real problems. And with an engineering course focused on topics of real interest to students, these teachers are going to have an answer with real meaning.

Preparedness. Sadly, less than 15% of U.S. high school graduates complete a sufficiently rigorous program in math and science to be successful in a typical collegiate engineering program. Having been exposed to engineering while still in high school, students with an interest in obtaining an engineering degree learn early that they must complete mathematics up to pre-calculus (or even better calculus) and physics to have a realistic chance of being admitted into and completing an engineering degree.

Greater good. High school is society's opportunity to ensure that young adults learn material that is fundamental and important not only to them, but to all of us. In the past, society has said that chemistry is important, biology is important, and algebra is important—so we teach these subjects in high school. Today, no one doubts that engineering and technology are important and will only become increasingly more important over time. Because of this challenge and opportunity, we must work diligently to ensure that engineering is part of the typical student's high school experience—our society requires this response.

GEOFFREY C. ORSAK, *Executive Director, Institute for Engineering Education at SMU*
Southern Methodist University
Dallas, TX 75275 USA

Geoffrey C. Orsak received the B.S.E.E., M.E.E., and Ph.D. degrees in electrical and computer engineering from Rice University, Houston, TX, in 1985, 1986, and 2000, respectively.

Currently, he serves as Executive Director of the new federally funded Institute for Engineering Education at SMU, Dallas, TX. In addition, he serves as Associate Dean for Research and Development and Professor of Electrical Engineering in the School of Engineering at SMU. He is the chief architect and Director of the nation's leading high-tech K-12 engineering education program—the Infinity Project—and is also creator of Visioneering, one of the country's signature events for school-age children aired during National Engineers Week.