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Democratizing Engineering for Every High School Student

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Offering engineering classes to high school students can empower them to create change in their local communities and encourage them to pursue careers in the field.

A DISCUSSION OF

The Next 75 Years of Science Policy

One of the greatest and most enduring strengths of the United States has been its ability to attract global talent in science, technology, engineering, and mathematics (STEM) to bolster its economic and technological competitiveness. To this end, the White House recently announced new actions and pathways for international STEM scholars, students, researchers, and experts to contribute to innovation and job creation efforts across the United States. But

it is also crucial to recognize the importance of increasing and training the domestic workforce of scientists—especially engineers. The nation's current STEM shortages within research, development, and innovation communities cannot be addressed solely by attracting more global talent.

Indeed, the United States is facing a crisis in its K–12 pipeline. According to data from the National Student Clearinghouse Research Center, the percentage of US high school students enrolling directly in college in 2020 showed an "unprecedented" decline of between 4% and 10%. And while the US Bureau of Labor Statistics predicts STEM jobs will grow twice as fast as other occupations by 2029, research continues to show high school students have declining interests in STEM fields.

The gap in the US STEM pipeline is exacerbated by the large proportion of international graduates who either return overseas or work for foreign companies that compete with US companies. According to the 2020 Industrial Capabilities Report to Congress, China is producing eight times as many STEM graduates per capita as the United States (despite its population being four times as large)—and the trend continues to worsen.

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This geopolitical dilemma requires a three-pronged response. First, the United States must make continued investments in basic scientific research. Second, the country must expand the pipeline of diverse STEM graduates. And third, engineering must be a requirement for every high school student. Together, these policies are an urgent national imperative.

With a growing number of high school graduates who are first-generation immigrants, from underrepresented minority populations, or both, it is abundantly clear that the nation's interests are best served by fueling the K–12 pipeline in ways that encourage more high school students from diverse backgrounds to pursue engineering programs. But how do educators inspire these students to discover engineering as their calling? Most students have a basic understanding that engineers "design and build things," but possess an extremely limited sense of what engineers actually do. Aggravating matters further, many students are intimidated by the math requirements and never consider the profession for themselves.

One successful approach to expanding the K–12 pipeline is the National Science Foundation-sponsored pilot program Engineering For US All (e4usa), which seeks to bring engineering principles, skills, and design experiences into the high school curriculum. As the National

Science Foundation's Don Millard puts it, e4usa attempts to "democratize engineering for every high school student." The program's novel 30-week curriculum requires only high school algebra as a prerequisite and focuses on four major themes: discovering engineering, engineering and society, engineering professional skills, and engineering practice.

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Several features of this program make it worth emulating. No prior knowledge of engineering is required and any teacher can be trained to deliver this first-of-its-kind engineering course. Students are empowered to create change in their local communities through exposure to problems that are personally meaningful or associated with society's grand challenges, including sustainability, clean water, and human health. Teaching techniques engage students in the creativity of engineering early in their education. Research has shown that consideration of differences in how students learn has a marked impact on student retention. And if universities can retain first-year students through completion of their engineering degrees, the number of engineers graduating in a given year could increase by as much as 40%.

After three years of implementation, e4usa is now in 50 high schools in 19 states, plus Washington, DC, and the US Virgin Islands. It has helped over 3,000 students across the United States. The demographics of the 2021–2022 cohort is approximately 42% underrepresented minority and 43% female and nonbinary genders. By every measure, this program is expanding the pipeline of diverse high school students interested in pursuing STEM degrees. Surveys of the first-year cohort showed 52 out of 82 participants going into STEM degree programs at either two-year or four-year schools. In addition, students can receive credit and placement at seven colleges and universities around the country.

Besides changing high school curricula, educators must also work to convince students of all backgrounds that pursuing an engineering career is not only possible but also deeply rewarding. The engineering of mRNA vaccines, for example, was performed at record speed and remains a wonder. When Kizzmekia Corbett, a leading coronavirus researcher and an African American woman at Harvard University, talks to young high school women, the first thing she wants them to know is that if she—raised in a tiny Southern town—can perform the groundbreaking research that led directly to the development of the Moderna COVID-19 vaccine, then so can they.

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These stories make a difference. The girls hang on her every word as Corbett explains that she could never have imagined completing her undergraduate degree at the University of Maryland, Baltimore County, working as a research fellow at the National Institutes of Health, and then joining the faculty of the Harvard T. H. Chan School of Public Health—before seeing her research successfully harnessed by Moderna to create a life-saving medical intervention in a global public health emergency. Incredible stories like Corbett's highlight how government investments in basic scientific research fuel the pipeline to future discoveries.

The COVID-19 pandemic has showcased the need for greater STEM investments and for a diverse workforce trained to develop new interventions, new processes, and new materials. Fortunately, Maryland's political leaders understood early in the pandemic the need to leverage the combined expertise of science, medicine, and engineering via formation of the COVID-19 Task Force. Thanks to this advice, the governor and state legislature have the enviable task of deciding how best to invest approximately $2.5 billion, the largest surplus in its history, after years of structural deficits. The next round of vaccine breakthroughs or game-changing technology may well come from a student who grew up in a small town or underprivileged community but who participated in a program like e4usa.

These engineers of the future will need the ingenuity of Nikola Tesla, the scientific insight of Albert Einstein, the creativity of Maya Angelou, the determination of the Wright brothers, the leadership abilities of Bill Gates, the conscience of Eleanor Roosevelt, and the vision of Martin Luther King Jr. The nation's economic competitiveness, military strength, public health, and standard of living depend on these values—and growing the domestic engineering workforce is an essential step to making this future possible.

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