



ENGAGE TO EXCEL: PRODUCING ONE MILLION ADDITIONAL COLLEGE GRADUATES WITH DEGREES IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

A Report by the President's Council of Advisors on Science and Technology

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Summary

A number of economic analyses suggest that if the United States is to maintain its historic preeminence in the fields of science, technology, engineering, and mathematics (STEM)—and gain the social, economic, and national security benefits that come with such preeminence—then it must produce approximately 1 million more STEM professionals over the next decade than are projected to graduate at current rates. To meet this goal, the United States will need to increase the number of students who receive undergraduate STEM degrees by about 34% annually over current rates.

Encouragingly, while this need may seem daunting, it can be accomplished with only a modest increase in the retention rate of STEM majors during the first few years of college. That's because fewer than 40 percent of students who enter college intending to major in a STEM field complete college with a STEM degree today. Increasing the retention of STEM majors to just 50 percent would, alone, generate approximately three-quarters of the targeted 1 million additional STEM degrees over the next decade by increasing the annual number of graduates with bachelor or associate degrees in STEM fields to about 370,000 from the current 300,000. Experience says that's possible. At one U.S. university, for example, a combination of programs that better prepared high-school students for life as STEM majors, increased student research opportunities, and improved teaching practices boosted graduation rates in STEM disciplines by nearly 50%.

In its latest report, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*, the President's Council of Advisors on Science and Technology (PCAST) concludes that retaining more STEM majors is the lowest-cost, fastest policy option to provide the STEM professionals that the Nation needs for economic and societal well-being. Among other benefits of this approach, it does not require expanding the number or size of introductory courses, which are already constrained by space and resources at many colleges and universities.

In its report, PCAST provides a strategy for achieving increased retention of STEM majors on the scale required—a strategy based in part on the reasons students give for abandoning STEM majors, including uninspiring introductory courses, difficulty with the required math, and an academic culture in STEM fields that is sometimes not welcoming or attuned to members of groups underrepresented in STEM fields—including women and minorities, who today constitute about 70 percent of college students but earn only 45 percent of STEM degrees.

Recommendations

Three imperatives underpin the recommendations in PCAST's report:

- Improve the first two years of STEM education in college.
- Provide all students with the tools to excel.
- Diversify pathways to STEM degrees.

In addition to its call to create a Presidential Council on STEM Education to help implement and expand upon PCAST's recommendations, the report's major policy recommendations—applicable to technical and community colleges as well as four-year colleges and universities—are:

1. Catalyze widespread adoption of empirically validated teaching practices.

Studies have shown that classroom approaches that engage students as active participants improve retention of information and critical thinking skills and can significantly increase STEM-major interest and perseverance, compared with conventional lecturing. In one study, for example, students in traditional lecture courses were twice as likely to leave engineering and three times as likely to drop out of college entirely compared with students taught using active learning techniques. In another study, students in a physics class that used active learning methods learned twice as much as those taught in a traditional class, as measured by test results.

These evidence-based teaching methods do not necessarily require more resources than traditional lectures, but most faculty lack experience using these methods and are unfamiliar with the vast body of research indicating their impact on learning. The Federal Government could have a major impact by supporting programs that provide training for faculty in evidence-based teaching methods and materials, and by supporting the development of tools to measure progress in this domain.

2. Advocate and provide support for replacing standard laboratory courses with discovery-based research courses.

Too often, even the “active learning” elements of today's teaching regimens—laboratory courses— simply repeat classical experiments rather than engaging students in compelling experiments with the possibility and excitement of true discovery. One study found, for example, that college sophomores who engaged in research projects with a professor were significantly less likely to leave STEM majors than those who did not. The Federal Government should support the scale-up of model research and design courses and change Federal rules to allow the expansion of opportunities for student research and design in faculty research laboratories.

3. Launch a national experiment in postsecondary mathematics education to address the math preparation gap.

Nearly 60 percent of students enter college without the math skills needed for STEM majors. This not only limits students' ability to enter these careers, but costs a great deal—colleges spend at least \$2 billion per year on developmental education for underprepared students. The Federal Government should support an initiative to reduce the math bottleneck, focusing on: summer and other bridge programs for high school students entering college; improved remedial courses for college students; new college math curricula developed and taught by scientists and engineers who are not mathematicians, and; producing more K-12 mathematics teachers from non-math-major science and engineering graduates.

4. Encourage partnerships among stakeholders to diversify pathways to STEM careers.

The conventional educational “pipeline” to STEM competency and accomplishment should be replaced by a more diverse set of pathways to attract and retain STEM students with backgrounds atypical of traditional STEM students. With the assistance of Federal programs and public-private partnerships, 2- and 4-year institutions should make new connections among themselves and with other institutions to provide more entry points and pathways to STEM degrees. These connections should reach beyond current partnerships between community and technical colleges and private-sector employers to encourage scientific research and engineering design exchanges across two- and four-year institutions.

Conclusion

PCAST's recommendations, many of which could be implemented by refocusing current STEM investments, address the most significant barriers to STEM student retention and have the potential to inspire and catalyze change in America's college classrooms. Their implementation will provide students with the skills they need to fill 21st century American jobs and provide the United States with the workforce it needs to be innovative and competitive for decades to come.

PCAST is an advisory group of the nation's leading scientists and engineers who directly advise the President and the Executive Office of the President. For more information, please visit www.whitehouse.gov/ostp/pcast.