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Engage to Excel

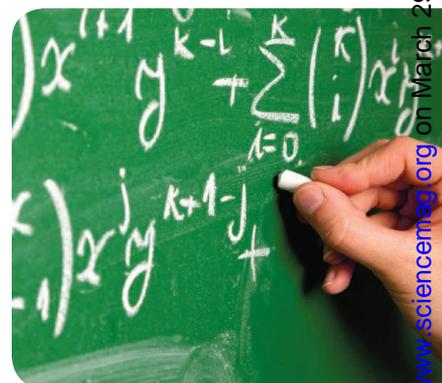
IN 2010, WE AND OUR COLLEAGUES ON THE PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE and Technology (PCAST) released a report entitled *Prepare and Inspire: K-12 Education in Science, Technology, Engineering and Math (STEM) Education for America's Future*. This important report advocates preparing all students to use STEM in their personal and professional lives and inspiring them to learn STEM subjects and pursue STEM careers. But in the United States, over 60% of students who enter college intending to major in a STEM field fail to graduate with a STEM degree. Because economic analyses forecast that the United States will need 1 million more STEM graduates over the next decade than will be produced by our current modes of education,* reducing this dropout rate is the focus of a second report we released last month, called *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*.†

Why do undergraduate students leave STEM during the first 2 years? Studies indicate three primary reasons: uninspiring introductory courses, difficulty with the required math, and an academic culture in STEM fields that is often unwelcoming. These problems can be especially severe for members of groups underrepresented in STEM fields, including women and minorities, who today constitute about 70% of college students but earn only 45% of STEM degrees.

Engage to Excel recommends that the federal government catalyze widespread adoption of empirically validated teaching practices, including active learning approaches using case studies, problem-based learning, peer instruction, and computer simulations. Classroom approaches that engage students actively increase retention of information, build critical thinking skills, induce more positive attitudes toward STEM disciplines, and strengthen retention of students in STEM majors. In one study, students learned twice as much in a large physics course taught with active learning techniques than did students taught in a parallel class by lecture.‡

The current system delays the hands-on research and internship experiences that capture the thrill of inquiry and discovery for STEM majors until the third and fourth years of college, when many students have already opted out. One study found that college sophomores who engaged in research projects with a professor were much less likely to leave STEM majors than those who did not.§ The government should therefore 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 engage students in compelling experiments with the possibility and excitement of true discovery. Examples of good alternatives can be found among the winners of *Science's* IBI Prize, as represented on pp. 1588 and 1590 of this issue. The government should also launch a national experiment in postsecondary mathematics education to address the mathematics preparation gap. Nearly 60% of students enter college without the mathematics skills needed for STEM majors. This not only limits students' ability to enter STEM careers, but costs a great deal: Colleges spend approximately \$2 billion per year on developmental education.

PCAST's recommendations, many of which could be implemented by refocusing current STEM investments, address the most substantial barriers to STEM student retention and have the potential to catalyze change in America's college classrooms. Their implementation will give students the skills they need to fill 21st-century jobs and give the United States the workforce it needs to be innovative and competitive. — S. James Gates Jr. and Chad Mirkin



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*D. Langdon, G. McKittrick, D. Beede, B. Khan, M. Doms, *ESA Issue Brief* 03-11 (Economics and Statistics Administration, U.S. Department of Commerce, Washington, DC, 2011). †http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf. ‡L. Deslauriers, E. Schelew, C. Wieman, *Science* **332**, 862 (2011). §B. A. Nagda, S. R. Gregerman, J. Jonides, W. von Hippel, J. S. Lerner, *Rev. Higher Educ.* **22**, 55 (1998).