WOMEN AND STEM

PREPARING FOR A TECHNOLOGY-DRIVEN ECONOMY

BOTH RESEARCH AND PRACTICE HAVE shown that women and girls are as adept at science, technology, engineering, and math (STEM) as their male counterparts. Given equal opportunity, girls and women can excel in STEM fields. With global competitiveness increasingly linked to building a technologically proficient workforce, ensuring that women and girls have equal access to STEM education is vital for this country's future economic growth.

As opportunities to study and work in STEM have increased over the past 45 years, girls and women have gained ground in many fields, particularly biological, environmental, and chemical/material sciences. Opening opportunity has benefited men as well, as some fields traditionally occupied by women, notably in healthcare, have become more broadly accessible.

Yet gender bias still persists at all levels of education, from subtle differences in encouragement to outright discrimination. Such biases

contribute to an ongoing gender gap in key areas such as engineering and computer science, preventing women from entering fields where workforce need is high—and where innovation will be crucial for both economic expansion and national security. Complying with Title IX can help close this gap through measures to ensure equal access to STEM-related courses and activities, recognize and address gender biases, and ensure equality in academic admissions and employment.

Behind the Gender Gap: Ability or Bias?

Although the stereotype persists that boys are innately better than girls at math and science, recent trends in achievement, combined with years of scientific research, prove that this notion is simply incorrect. Cultural factors, including opportunity, gender bias, and stereotyping, all affect participation and performance in STEM.

The varying participation of women in STEM in different parts of the world demonstrates the impact of culture. For example, while just 14.9% of engineers in the United States were women as of 2013,[1] in Romania 51% of researchers in engineering and technology are women.[2]

Education opportunity clearly makes a difference. A European Commission study that looked only at highly educated men and women in Europe (those with tertiary education) found virtually no gender difference in STEM careers across 28 countries, with 56.5% of such women working in science and technology, compared with 56.6% of men. Even within this select group, culture plays a role, with notable differences among countries. For example, in Lithuania, 65.5% of highly educated women worked in science and technology, compared with 46.0% of men; in Malta the figures were 66.7% for men and 54.5% for women.[3]

KEY FINDINGS

1. **Gender bias can prevent girls and women from pursuing an education in STEM;** it can also deter men from studying certain fields. Ensuring equal access to STEM education can increase overall participation in fields that are driving economic opportunity.
2. **Both interest and achievement in STEM are at an all-time high among high school girls,** yet female students are still less likely than their male peers to go on to study and work in STEM fields.
3. **Although women have made impressive gains in STEM at the postsecondary level, attrition remains high** at every stage, from undergraduate school through professorship. In addition, women continue to lag in key fields such as engineering and computer science. This loss of talent comes at a devastating cost to U.S. competitiveness.
4. **Outreach and retention programs, family-friendly faculty policies, and stronger monitoring of regulatory compliance** would help ensure that our nation's schools, colleges, and research institutions are able to retain women in STEM. These actions will vastly expand the country's capacity for technological innovation.
5. **Compliance with Title IX provisions relating to STEM education is essential** to take full advantage of the potential of both men and women to advance in technology, health, and related fields.

CULTURAL BIAS AFFECTS PERFORMANCE

A large body of research has found that cultural bias affects student interest and performance in STEM.[4] One recent multinational study demonstrated that a society's bias against women in science is linked to gender differences in aptitude. The study compared the scores of 300,000 eighth graders in 34 countries

> Our science, technology, engineering and math (STEM) workforce is crucial to America's innovative capacity and global competitiveness. Yet women are vastly underrepresented in STEM jobs and among STEM degree holders…. That leaves an untapped opportunity to expand STEM employment in the United States, even as there is wide agreement that the nation must do more to improve its competitiveness."
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> *WOMEN IN STEM: A GENDER GAP TO INNOVATION*, ECONOMICS & STATISTICS ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE, 2011.

on a standardized math and science test with population scores on the Implicit Association Test on gender and science—the standard test for detecting unconscious bias, developed by researchers at Harvard. The study shows a strong association between a country's gender bias about science and the gender difference in test scores of students in that country.[5]

This evidence corroborates that gender differences in math and science performance stem from cultural, rather than biological, factors. Where gender bias is low, female performance is correspondingly high.

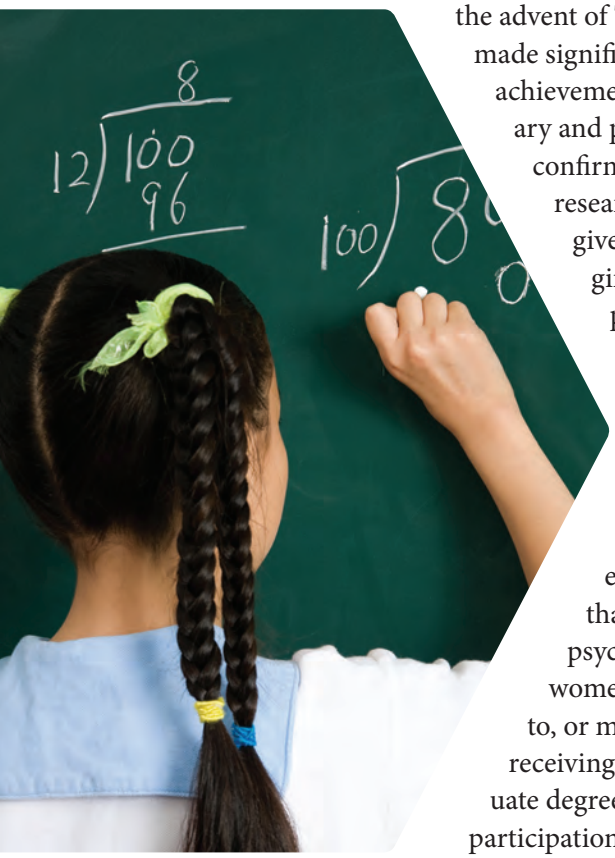
In addition to hindering performance, gender biases can affect whether girls and women choose to enter and stay in STEM fields. They may prevent female students from studying science and math in school or influence whether teachers encourage them to pursue science and engineering careers. They may also directly or indirectly influence hiring and promotion of women in the STEM workforce.

NEUTRALIZING STEREOTYPES BOOSTS ACHIEVEMENT

Stereotypes about girls' math and science ability can affect their achievement through an effect called "stereotype threat"—the feeling of being judged by a negative stereotype, or fear of reinforcing that stereotype. Stereotype threat is known to impede girls' performance. In one landmark study, girls who were primed to feel inadequate did significantly worse than their male peers on a challenging math test, whereas girls in the control group, who did not face a stereotype threat condition, scored similarly to the boys.[6] In the decade and a half since that investigation appeared, hundreds of additional studies have been published that support this finding.

Recent gains in girls' mathematical achievement demonstrate the impact of culture and learning environments on students' abilities and interests. As learning environments have become more open since the passage of Title IX, girls' achievement has soared. For example, the proportion of girls who score in the top 0.01% of seventh and eighth graders on the math SAT rose from 1 in 13 in the early 1980s to 1 in 3 more recently.[7] This short-term closing of the gender gap provides further evidence that gender differences in math ability are not innate.

Advances and Obstacles in STEM Education



Under Title IX, education programs that receive federal funding must ensure equity in STEM education for all students. Since the advent of Title IX, women have made significant gains in STEM achievement at both the secondary and postsecondary levels—confirmation in practice of research suggesting that given equal opportunity, girls and women will perform at an equal level to boys and men.

Progress has not been uniform across disciplines, however. Government education statistics show that in fields like biology, psychology, and chemistry, women now make up close to, or more than, half of those receiving bachelor's or postgraduate degrees. At the same time, participation rates of women and girls in secondary and postsecondary technical fields, particularly engineering and computer science, are still very low.[8] Given the importance of these fields for the ongoing development of the national and global economies, more needs to be done to achieve true gender parity in STEM.

PRIMARY AND SECONDARY EDUCATION

Among primary and secondary school students, the gender gap in math and science is closing, but results in some areas are mixed. For example, science scores on the 2015 National Assessment of Educational Progress (NAEP) were the same for males and females in grade 4 but had a several-point gap in grades 8 and 12. The gap resulted from scores in physical and space sciences, while scores in life sciences showed little or no difference.[9] The reasons for these later, discipline-specific gaps are unclear; lack of role models or encouragement for girls in traditionally male-dominated fields like physics or astronomy may affect interest and therefore performance.

In high school, girls have caught up with boys in number of credits earned in math and science, with steady increases since 1990 (Figure 1). Both interest and achievement in STEM are at an all-time high, with females participating in more school-sponsored math and science activities and earning higher grades in these fields than their male peers. Gaps in specific areas of study persist at this level, with girls more likely than boys to take biology, chemistry, and precalculus and less likely to take physics.[10]

Even with girls' growing participation and success in math and science at the K–12 level, this academic success very often does not translate into college and career choices in STEM. Girls are taking more advanced placement (AP) classes overall, but fewer go on to take AP tests in STEM fields, and the differences across subject areas are pronounced. According to the College Board, which administers the AP exam, in 2016 61% of students who took the AP test in biology were girls, compared with just 23% of those who took the test in computer science.[11] (There is a bright spot here, in that the percentage of girls taking the computer science exam is up from 17% in 2009.)[12] The participation rate of girls in STEM-related programs of study in high school career and technical education similarly lags, at 20%.[13]

Encouraging girls to consider entering these high-growth areas is an important step in moving toward full equality. This will in turn unlock the potential for greater economic opportunity—not just for women and their families but for the country as a whole.

POSTSECONDARY EDUCATION

Gaps in women's pursuit of technical fields carry through to postsecondary studies. Across all levels of higher education (less than bachelor's through postgraduate/professional), women received more STEM degrees than men in 2012–13 (63%), but the bulk of these were in healthcare, where women received 82% of all degrees. Among the "core" STEM fields, which do not include healthcare, women earned more life sciences degrees (58%), while men received the vast majority of technician (85%), engineering (80%), and computer science (77%) degrees.[14] (Core STEM fields include engineering, life sciences, physical sciences, computer and information technology, and math.)

With a growing number of students choosing community college as their first college experience, the STEM gender gap on community college campuses across this country is concerning. In 2014, only 21.7% of associate's degrees in STEM were earned by women. Although the total number of women earning such degrees increased over the prior five years—from under 17,000 in 2009 to just over 20,000 in 2014—the percentage of STEM associate's degrees going to women has actually declined slightly since 2009.[15]

> "We look at science as something very elite, which only a few people can learn. That's just not true. You just have to start early and give kids a foundation. Kids live up, or down, to expectations."
>
> MAE JEMISON, FIRST BLACK WOMAN IN SPACE

At the undergraduate level, women are less likely than men to concentrate on a core STEM field. In 2014, just 7.9% of female freshmen indicated that they planned to major in engineering, math, statistics, or computer science, compared with 26.9% of males (Figure 2). In one spot of good news, figures for both groups were at ten-year highs in 2014, with

ENCOURAGING GIRLS IN MATH AND SCIENCE

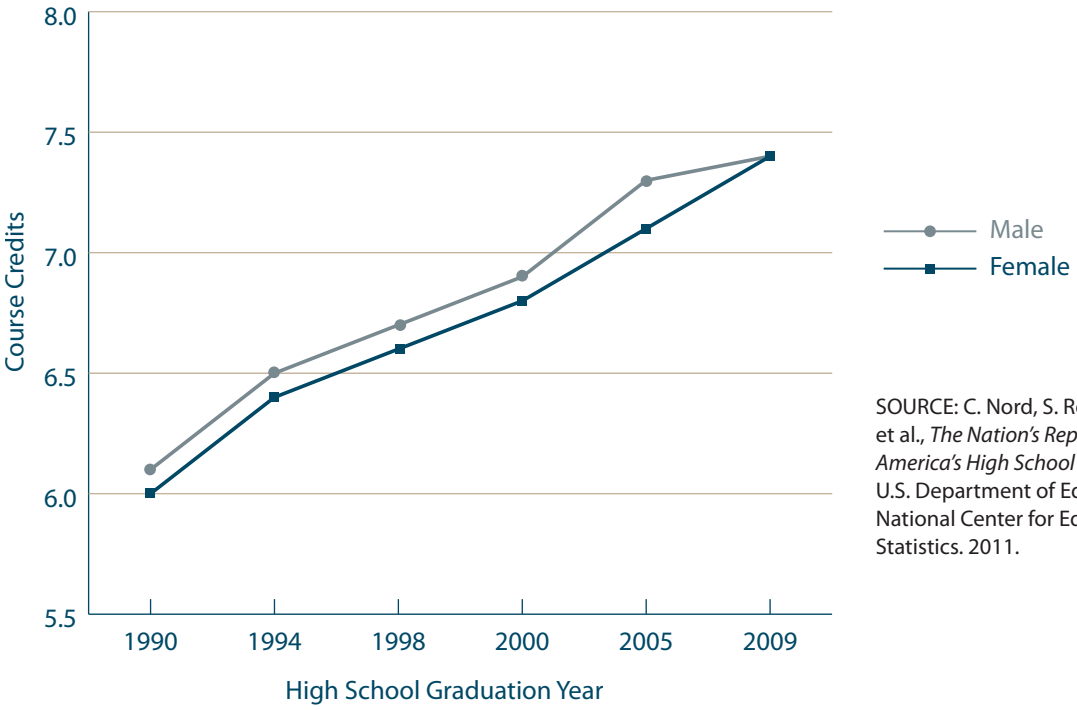
Following are research-based suggestions for encouraging girls in math and science at the primary and secondary school levels.

1. **Teach students that academic abilities are expandable and improvable.** Students who are more confident about their abilities in math and science are more likely to take elective math and science courses in high school and to choose STEM-related college majors and careers.
2. **Provide students with prescriptive, informational feedback about their performance**. Feedback that focuses on strategies, effort, and the process of learning enhances students' beliefs about their abilities and improves both persistence and performance on tasks.
3. **Expose girls to female role models who have succeeded in math and science.** Exposing girls to female role models (e.g., through biographies, guest speakers, or tutoring by older female students) can help invalidate the stereotype that men are better than women in math and science.
4. **Create a classroom environment that sparks curiosity and fosters long-term interest.** Teachers can 1) choose activities connecting math and science to careers in ways that do not reinforce gender stereotypes, and 2) provide ongoing resources for students who continue to express interest in a topic.
5. **Provide spatial skills training.** Training in spatial skills is associated with performance in mathematics and science.

Source: *Encouraging Girls in Math and Science: IES Practice Guide,* U.S. Department of Education, 2007. See https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/20072003.pdf.

FIGURE 1

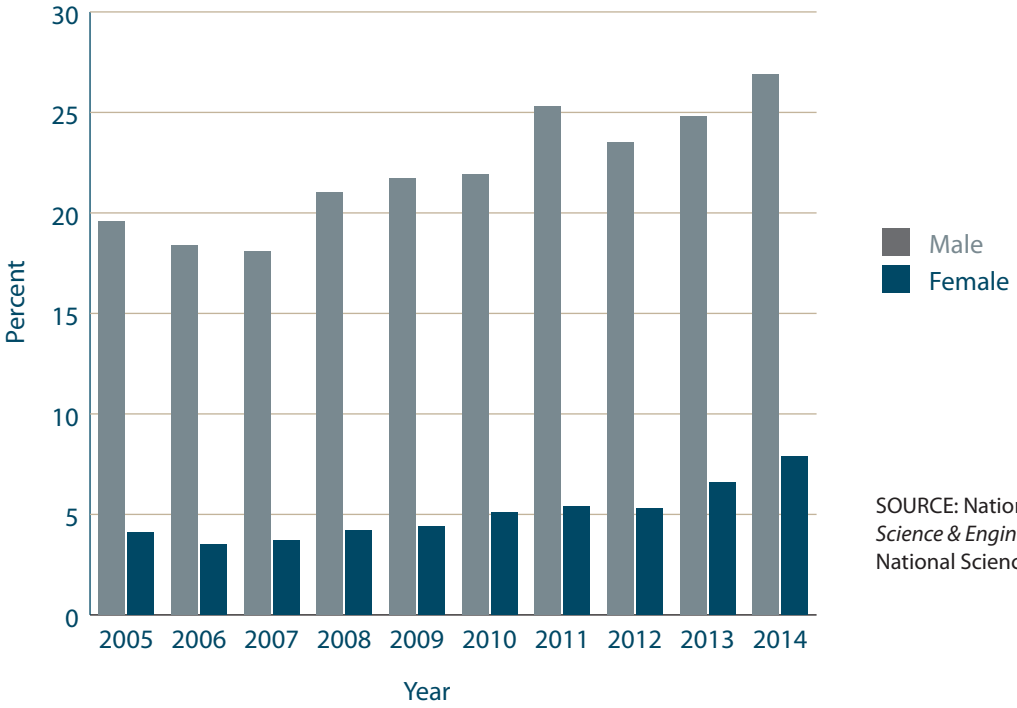
Average High School Credits Earned in Math and Science, by Gender, 1990–2009



SOURCE: C. Nord, S. Roey, R. Perkins et al., *The Nation's Report Card: America's High School Graduates.* U.S. Department of Education, National Center for Education Statistics. 2011.

FIGURE 2

Percent of College Freshmen Indicating Intent to Major in Engineering, Math, Statistics, or Computer Science Fields, 2005–2014



SOURCE: National Science Board, *Science & Engineering Indicators 2016.* National Science Foundation, 2016.

The loss of women in STEM majors results in a major missed opportunity to expand our technical workforce.

women seeing the biggest one-year uptick in the past decade. The overall trend in women's attainment of STEM bachelor's degrees since 2000 is sobering, however. While women's share of degrees in biological and agricultural sciences has increased slightly, it has remained flat in most STEM fields and has actually fallen in math and computer science (Figure 3).

Retaining women in STEM courses of study is an important priority. Although they are less likely to drop out than their male counterparts, women who start off in a STEM major are more likely to switch to a non-STEM major (Figure 4). The loss of women in STEM majors results in a major missed opportunity to expand our technical workforce.

Culture is likely a bigger culprit here than course content. Studies have found that culture, including harrassment or simply a lack of female graduate students, can affect women's persistence in STEM.[16] One review of student enrollment in STEM courses over a nine-year period found that attrition varied greatly by field. For example, the proportion of women taking computer science declined from 31% in the first semester to just 17% in the fourth semester, while female participation in biology increased over the same period. High attrition in many STEM fields signals a cultural problem that needs to be addressed through

ENSURING GENDER EQUITY IN COLLEGE STEM PROGRAMS

Colleges and universities can ensure equitable access to STEM education with a few simple measures, some of which are required by Title IX:

Admissions. STEM departments can eliminate some prerequisites and offer multi-level first-year courses to expand opportunities for women who may not have taken advanced high school courses or AP tests in STEM.

Recruitment. Colleges can partner with K–12 schools in their community to help all students prepare for higher education in STEM fields, provide mentors, and recruit promising students.

Scholarships and fellowships. By periodically examining financial assistance data, STEM departments can ensure that subtle gender bias has not crept into the awarding of assistantships—e.g., female students primarily getting teaching assistantships and male students receiving research assistantships.

Counseling and appraisal materials. If a school finds that a disproportionate number of students enrolled in a major are men, it must review its policies and materials to ensure that this imbalance is not due to academic advisors steering females away.

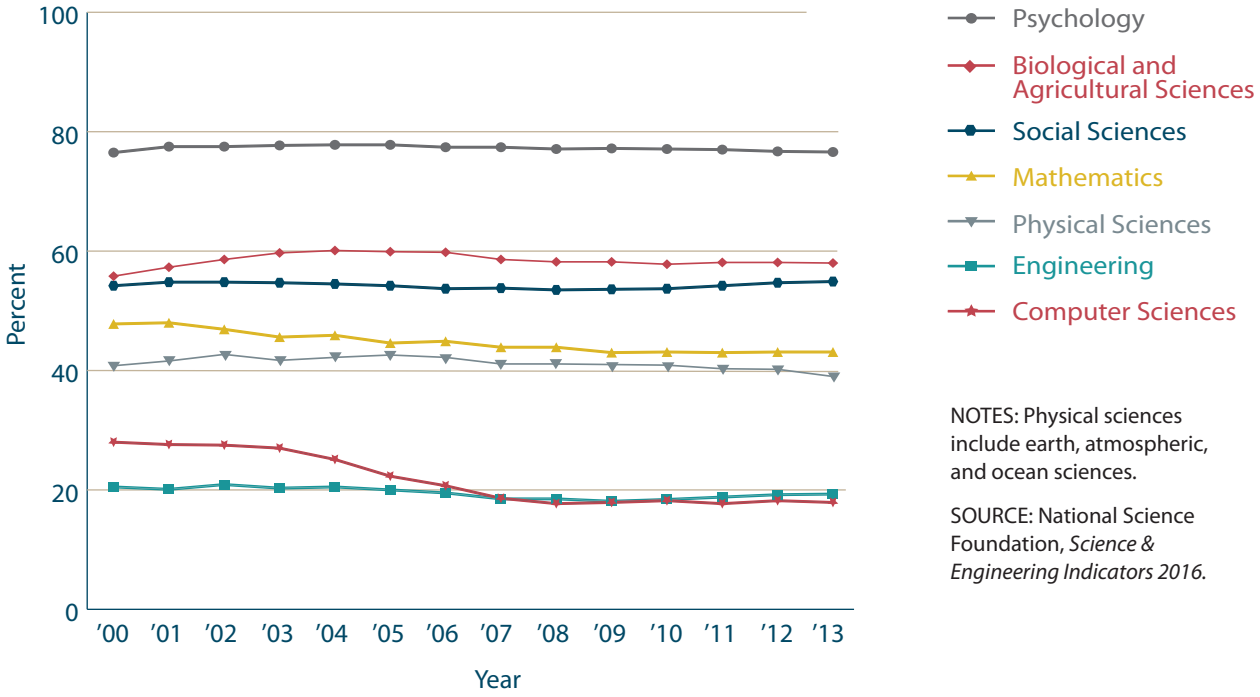
Administration of courses. STEM departments can consider how to make better use of their existing class and program evaluation tools to assess whether their program administration treats female and male students equally.

Harassment. If a school is made aware of any harassment based on gender, whether originating from students or from faculty or staff, it must take steps to end the conduct, eliminate the hostile environment, and prevent its recurrence.

SOURCE: Adapted from *Title IX and Access to Courses and Programs in Science, Technology, Math, and Engineering (STEM),* U.S. Department of Education, Office for Civic Rights, 2012. See https://www2.ed.gov/about/offices/list/ocr/presentations/stem-t9-powerpoint.pdf

FIGURE 3

Women's Share of Science and Engineering Bachelor's Degrees, by Field, 2000–2013

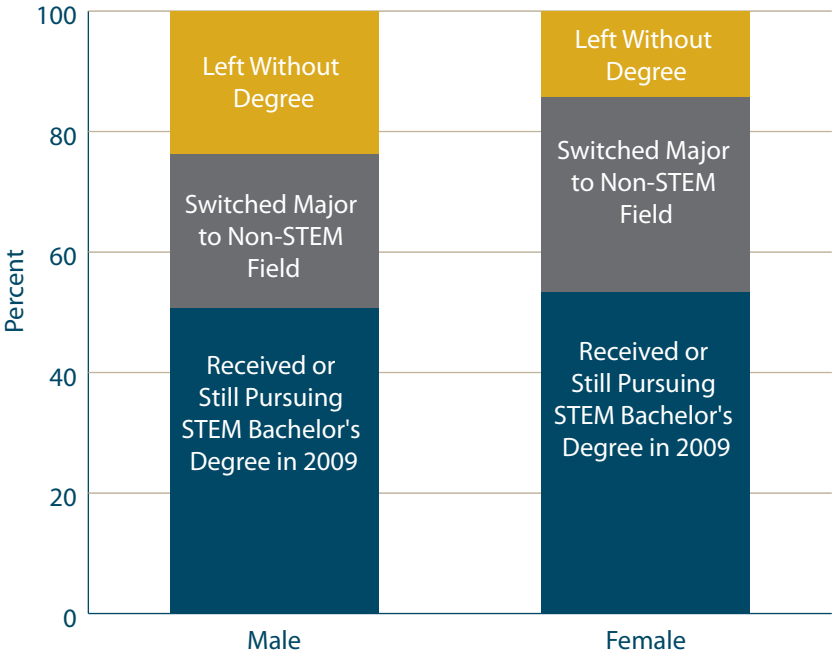


NOTES: Physical sciences include earth, atmospheric, and ocean sciences.

SOURCE: National Science Foundation, *Science & Engineering Indicators 2016.*

FIGURE 4

2009 Outcomes of 2003–2004 Beginning STEM Bachelor's Degree Students



NOTES: "Left Without Degree" includes students who dropped out of college. STEM includes mathematics, physical sciences, biological/life sciences, engineering, and computer and information sciences.

SOURCE: X. Chen and M. Soldner, *STEM Attrition: College Students' Paths Into and Out of STEM Fields.* U.S. Department of Education, National Center for Education Statistics, 2013.

institutional and attitudinal changes as well as broader participation of women in STEM.

At the postgraduate level, women have continued to gain ground in recent years, although again with wide variation by field. The overall proportion of science and engineering doctoral degrees earned by women grew from 43% in 2000 to 48% in 2013, with the greatest gains in the natural sciences.[17] The number of engineering doctoral degrees earned by women doubled during this period, with their proportion of these degrees climbing from 16% to 22%. Although women have made gains in nearly all fields, they still earned fewer than a third of doctorates awarded in math, physical sciences, and computer science in 2013.

With technology governing much of global industry, and with cybersecurity issues affecting everything from the protection of individuals' data to national safety threats, ensuring that half of the workforce has access to technology learning at all levels is essential. In addition, bringing a diversity of ideas to the technology workplace can strengthen both innovation and quality.

Academia: An Opportunity for Advancement

Since the passage of Title IX, the number of women doctorates employed in academia in STEM fields has increased tenfold, reaching approximately 114,000 in 2013.[18] The share of women in all faculty ranks has risen consistently, reaching 24% of full professors, 38% of associate professors, and 45% of assistant professors in 2013 (Figure 5).

Despite these gains, women are less likely than men to be promoted to full professorship, tenure status, and the highest ranks of academia, such as deans and department chairs.[19] This gap reflects a tradition of institutional practices that make it difficult for women to advance through the ranks of academia.

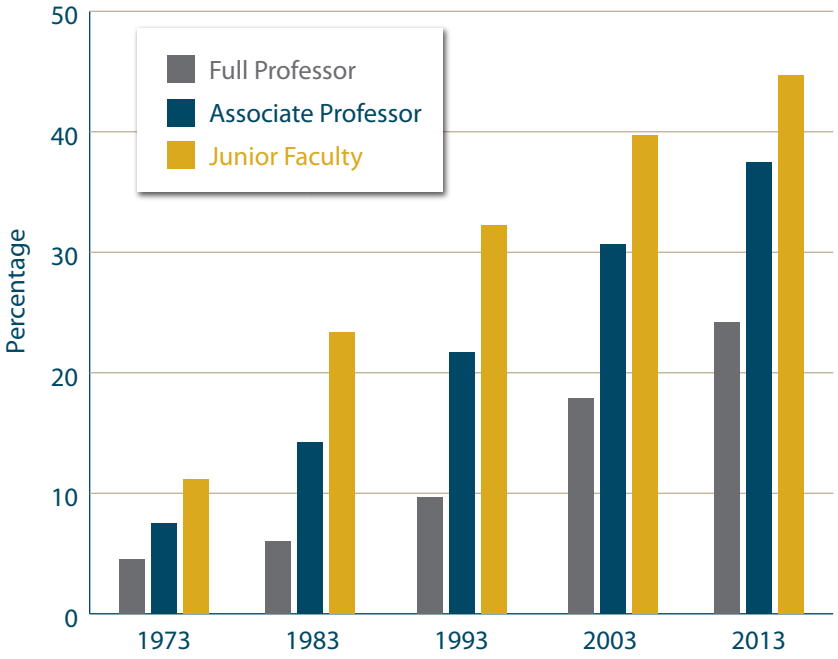
The academic pipeline for women in STEM fields is perpetually leaking, with the attrition of women outpacing that of men at all levels, from undergraduate school through tenured professorship. Even though many women persist through the attainment of a PhD, attrition continues at each step of career transition and promotion.

Part of the problem is that the tenure track often coincides with prime childbearing age for female academics, which can harm their chances for advancement. Typically, faculty members who do not receive tenure within a certain amount of time after obtaining a PhD will be encouraged to leave, although some institutions allow them to remain at the lower adjunct or assistant professor level. Women who have babies are 29% less likely to enter a tenure-track position than those who don't, while having children has little effect on men's likelihood of attaining promotions or tenure. Overall, women are 25% less likely to attain full professorship than men.[20]

For faculty members who take time off to raise families, the lack of supportive policies is detrimental to their careers and ultimately harmful to the STEM workforce. Implementing flexible options, such as stop-the-tenure-clock policies for all faculty who need to take care of children or other family members, can help create a supportive culture that will filter through all levels of higher education, ultimately improving the country's ability to produce technologically skilled workers.

FIGURE 5

Women as a Percentage of Science & Engineering Doctorate Holders Employed Full Time in Academia, by Academic Rank, 1973–2013



NOTES: Academic employment is limited to U.S. doctorate holders employed at 2– or 4-year colleges or universities, medical schools, and university research institutes, excluding those employed part time who are students or retired. Junior faculty includes assistant professors and instrocutors in 1973, 1983, and 1993; in 2003 and 2013, junior faculty includes assistant professors.

SOURCE: National Science Foundation, *Science & Engineering Indicators 2016*.

Expanding the U.S. STEM Workforce

As in academia, culture and expectations can make advancement in the workplace difficult for women in STEM careers, particularly those with family obligations. According to National Science Foundation (NSF) statistics, women comprise 47% of the total U.S. workforce, including more than half of all professional and related occupations, but only 25.5% of workers in STEM fields.[21]

The range of female participation in different STEM careers varies widely. According to new figures from the NSF, 48% of the workforce in life and biological sciences is female, up from 40% in 2006. In contrast, the proportion of women working in engineering is still extremely low. Women made up 15% of engineers in 2015, up from 6% in 1983 but only a slight gain over the 2006 figure of 12%. In mathematics and computer science, the proportion of women in the workforce continues to decline, from 31% in 1983 to 27% in 2006 and less than 25% in 2015.[22] It is unlikely that women's ability in these fields has deteriorated, so this decline more likely reflects working conditions or other factors that impede female participation.

> "I would not trade working as an engineer for anything, and am incredibly motivated to continue in the hopes that things are easier for the women following after me."
>
> LATINA ENGINEER

At the same time, men have made gains in several areas within healthcare that have traditionally been dominated by women, a finding that highlights the benefits of equal opportunity in STEM for all workers. For example, men made up 22% of health technicians in 2015, up from 16% in 1983. Similarly, men comprised

11% of registered nurses in 2015, up from just 4% in 1983 and 9% in 2006.[23]

In addition, corporations are letting employees take advantage of more flexible work options. In 1991, the Bureau of Labor Statistics found that only 14% of women had flexible work schedules. That number had climbed to 26% in 2007 and to 34% in 2012.[24] This flexibility will give female employees more opportunity to stay in their STEM careers.

As the global marketplace becomes more focused on technology and innovation, it's important to ensure that men and women have equal opportunities to participate and advance through the STEM pipeline. The attrition of women and girls from STEM fields does not benefit their male counterparts; rather, it removes major opportunities to increase our nation's economic competitiveness in science and technology. Institutional and workplace policies that promote the full participation of women are needed in order to take advantage of our nation's capacity for innovation.

WORKING ON WORKPLACE CULTURE

"When we wring our hands and ask why more women do not study STEM in schools, perhaps we should also look at how women are treated in the workplace after we get those STEM credentials." – FEMALE COMPUTER SCIENTIST

"It is disappointing how large, progressive companies still have the good old boy networks and silently expect women not to be in leadership roles." – FEMALE CHEMICAL ENGINEER

"The message I get over and over is that I am capable of getting things done right but I don't deserve the right to be promoted." – FEMALE AEROSPACE ENGINEER

"During my career, my workplace has become much more welcoming for women engineers, but there are still some lingering (and mostly subconscious) issues that arise." – MALE MECHANICAL ENGINEER

"I have noticed a direct correlation between a higher concentration of women in upper management and the attitude engineers show towards women. Having three women bosses right now I find the differing perspective and style quite refreshing." – MALE MECHANICAL ENGINEER

SOURCE: J. C. Williams, S. Li, R. Rincon, and P. Finn, *Climate Control: Gender and Racial Bias in Engineering?* Center for Worklife Law and Society of Women Engineers, 2016. See http://research.swe.org/climate-control.

Improving STEM Education and Research through Title IX

Title IX provisions mandate equal access to STEM courses and activities at the primary, secondary, and college levels as well as equal compensation, lab space, and institutional resources at research universities. In addition, federal agencies that award grants to education institutions are obligated to take steps to ensure that these institutions provide equal opportunities for women and girls in STEM education, including equal consideration in promotion and tenure for faculty.

Many students, and even educators, do not realize that Title IX applies to STEM. This means that compliance often goes unmonitored and infractions unreported. Compliance translates into equal treatment, from giving boys and girls the same level of encouragement in the classroom, to investigating whether substantial underrepresentation of women in STEM courses results from discriminatory practices, to ensuring that research assistantships are allocated fairly.

Increasing awareness of schools' responsibilities under Title IX can help close the STEM gender gap. The U.S. Department of Education and the White House have issued several briefs and other resources to help schools understand and fulfill their obligations.[25] Familiarizing themselves with these materials will allow Title IX coordinators and other school personnel to oversee compliance more effectively. On campuses and in national laboratories, adver-

RESOURCES ON WOMEN AND STEM

Solving the Equation: The Variables for Women's Success in Engineering and Computing. C. Corbett and C. Hill, American Association of University Women (AAUW), 2015. Available at http://www.aauw.org/research/solving-the-equation/.

Debunking Myths about Gender and Mathematics Performance. J. M. Kane and J. E. Mertz, *Notices of the American Mathematical Society,* January 2012. Available at http://www.ams.org/notices/201201/rtx120100010p.pdf.

Title IX and STEM: Promising Practices for Science, Technology, Engineering and Math. National Aeronautics and Space Administration (NASA), 2009. Available at https://odeo.hq.nasa.gov/documents/71900_HI-RES.8-4-09.pdf.

Why So Few? Women in Science, Technology, Engineering, and Mathematics. C. Hill, C. Corbett, and A. St. Rose, AAUW, 2010. Available at http://www.aauw.org/learn/research/whysofew.cfm.

Title IX Coordinators Guidance Package, U.S. Department of Education. Available at https://www2.ed.gov/policy/rights/guid/ocr/title-ix-coordinators.html.

Find Your Title IX Coordinator. AAUW. Available at http://www.aauw.org/resource/find-your-title-ix-coordinator/.

tisements or other awareness efforts would help boost compliance and therefore reduce the risk of institutions losing their federal funding.

Federal science agencies, which are responsible for ensuring that their academic grantees comply with Title IX, have an uneven track record in monitoring compliance. NASA has done consistent compliance reviews and has published Title IX resources, including a comprehensive best practices report that can be used as a model.[26] The Department of Energy (DOE) and other agencies have also conducted Title IX reviews. Some agencies have been less rigorous, however. A recent report by the U.S. Government Accountability Office (GAO) found that neither the Department of Defense (DOD) nor Health and Human Services (HHS) conducted required Title IX reviews between 2009 and 2013.[27]

In addition to lack of Title IX and STEM reviews, lack of good data on grant proposals and awards has made it difficult to monitor some agencies. The GAO report, which examined federal STEM research grants from six agencies for disparities in funding between women and men, found some inequities but also noted that poor data hindered analysis. The report concluded that this issue is serious enough to keep some agencies—specifically DOE, DOD, and NASA—from knowing whether they are meeting "their stated goals of funding the most qualified scientists."

To remedy this problem, the GAO recommends that these agencies collect additional data on grant proposals and awards, as well as that DOD and HHS conduct required Title IX compliance reviews. Such measures will help ensure that the government supports the most valuable STEM research while promoting equity among education institutions that receive funding.[28]

NCWGE Recommendations

- Current Department of Education guidelines for Title IX coordinators, which outline their responsibilities in ensuring equality in STEM education, should be broadly disseminated and publicized.
- Teachers should foster all students' interest in STEM by incorporating female as well as male role models into their teaching and encouraging students to take advanced classes and exams in STEM fields.

- Colleges and universities should examine their admissions and scholarship awarding practices to ensure that they do not foster discrimination. To forestall loss of talent, they should also establish standardized guidelines for tenure-track eligibility and offer a stop-the-clock option for women and men with small children.

- Federal, state, and local agencies should establish outreach and retention programs at the elementary, secondary, and postsecondary levels to engage girls and women in STEM activities, courses, and career development.

- All federal science agencies should conduct Title IX and STEM reviews and track grant award data to ensure that their grantee institutions are providing equal opportunities for women and girls in STEM, including education for students and promotion and tenure for faculty. This will help ensure that the country benefits from the work of its brightest minds.

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3. Ibid., p. 45.

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