



# Science, Technology, Engineering, and Mathematics

EQUALITY NARROWS THE ACHIEVEMENT GAP

**W**ITH GREATER OPPORTUNITY TO STUDY and work in science, technology, engineering, and math (STEM), girls and women have made significant progress in these fields over the past 40 years. Nonetheless, barriers to equality remain. Stereotypes about male and female abilities in math and science—which are perpetuated by society but have been debunked by scientific research—affect opportunities for girls

and women in STEM. Hiring and promotion practices in academia and elsewhere also can hold women back.

In a global marketplace that is increasingly driven by technology, leveling the playing field for women in STEM is an essential strategy for boosting U.S. competitiveness. Ensuring that all students have equal opportunities is key to creating an environment where talent and innovation can flourish in our schools, businesses, hospitals, research facilities, and government agencies.

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## Reasons for the STEM Gender Gap

The stereotype that boys are innately better than girls at math and science is pervasive in the U.S., but recent trends in achievement—as well as years of scientific research—dem-

onstrate that this notion is simply incorrect. Although the number of women still lags behind the number of men in many STEM fields, the reasons for this gap are cultural

## KEY FINDINGS

- 1. The achievement gap between male and female students** in science, technology, engineering, and math (STEM) is steadily closing, but cultural biases and institutional barriers still hinder the advancement of girls and women in these fields.
- 2. Despite overall gains, women’s participation in some STEM fields has stagnated or even declined in the past decade.** In addition, female attrition in STEM at every level of education is still high. This attrition comes at a devastating cost to U.S. competitiveness in the global marketplace.
- 3. Title IX compliance with regard to STEM education is essential** in order to take full advantage of the potential of our country’s best and brightest minds to advance technology and innovation.
- 4. Increased awareness of Title IX protections, outcome-based investments** in outreach and retention programs, institutional policies that ease restrictions on faculty who need time off to care for family members, and stronger monitoring of regulatory compliance would help ensure that our nation’s schools, colleges, and research institutions are fostering an environment that encourages women to stay and thrive in STEM fields.

rather than biological. The varying participation of women in STEM in different parts of the world demonstrates the impact of culture. For example, 40% of the students in the University of Puerto Rico at Mayaguez’s engineering programs are women,<sup>1</sup> and in Romania 44% of researchers in engineering and technology are women,<sup>2</sup> whereas only 11% of engineers in the United States are women.

### CULTURAL BIASES

Scientific research has not demonstrated that innate differences exist between boys and girls in terms of mathematical or scientific abilities. Spatial reasoning abilities and math performance are not biologically “programmed” by gender; rather, they are influenced by social

context and degree of gender equality in a society.<sup>3</sup>

The impact of cultural bias on student interest and performance in STEM fields is well studied. In a recent large-scale study, researchers Kane and Mertz (2012) demonstrated that the societal influence of gender stereotypes and bias against women in science is related to gender differences in aptitude.<sup>4</sup> They compared the scores of 300,000 eighth graders in 34 countries 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. Kane and Mertz’s study shows a strong link between the implicit gender-science stereotype of the country and the gender difference in test performance. This statistically significant correlation provides the most compelling evidence to date that differences between male and female students’ performance in math and science are caused by cultural, rather than biological, factors.

Implicit biases can have an impact on whether girls and women enter and stay in STEM fields. Gender biases can affect students in both overt and subtle ways. They may prevent female students from pursuing science and math from the beginning, play a role in their academic performance, and influence whether parents and teachers encourage them to pursue science and engineering careers. They may also directly or indirectly influence whether women are hired, as well as hinder the promotion rate and career advancement of female employees.

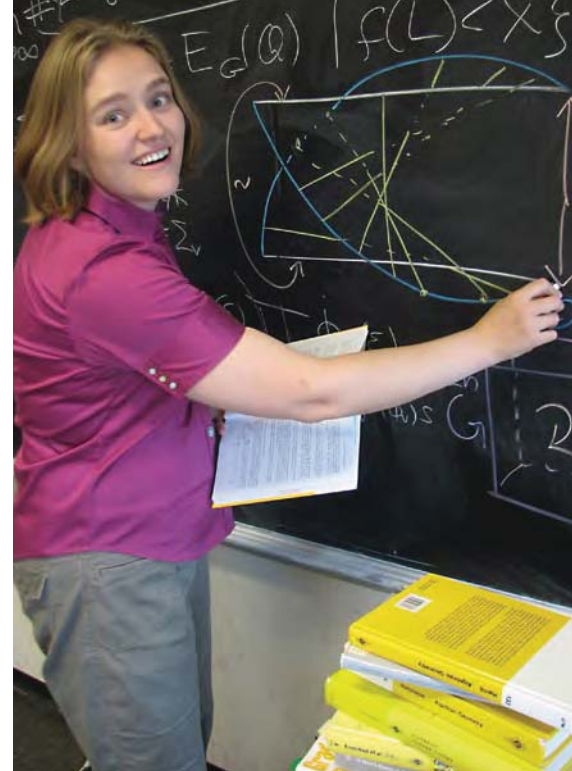
### STEREOTYPE THREAT

Stereotypes about girls’ math and science ability can affect their performance 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 negatively affect 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.<sup>5</sup> In the decade since that investigation appeared, some 300 additional studies have been published that support this finding.

Recent gains in girls' mathematical achievement demonstrate the importance 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.<sup>6</sup> This short-term closing of the gender gap provides further evidence that gender differences in math ability are not innate.



## Progress Since Title IX

Under Title IX, educational programs that receive federal funding are prohibited from discriminating on the basis of sex and must ensure equity in STEM education for all students. In addition, federal agencies that award grants to educational 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.

Women and girls have made great progress in many STEM areas, but more needs to be done to achieve true gender parity. In fields like biology, psychology, and chemistry, girls now make up close to, or more than, half of those receiving bachelor's or postgraduate degrees.

If girls are interested, they have the potential to go further.... There are still lingering stereotypes that affect girls in middle school, and they lose interest in the subjects.

—Physicist and astronaut  
Sally Ride,  
first U.S. woman in space

However, participation rates of women and girls in secondary and postsecondary technical fields, particularly

engineering and computer science, are still very low.<sup>7</sup>

## K-12 EDUCATION

Among secondary school students, the gender gap in math and science is closing. In high school, girls earn more credits and have higher grade point averages in math and science than their male peers.<sup>8</sup> Girls are more likely to take biology, chemistry, and pre-calculus than boys are, although they are less likely to take physics.<sup>9</sup> Despite these gains, the performance gap in standardized testing persists, as girls still perform lower than boys on the math SAT.<sup>10</sup>

Girls are taking more advanced placement (AP) classes overall, but fewer go on to take AP tests in STEM fields. According to the National Center for Education Statistics, in 2009 only 17% of students who took the AP test in computer science were girls.<sup>11</sup> The participation rates of girls in STEM-related programs of study in high school career and technical education continue to lag behind their participation in math and science, at only 20%.<sup>12</sup> 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 a college major and ultimately career selection in a STEM field.

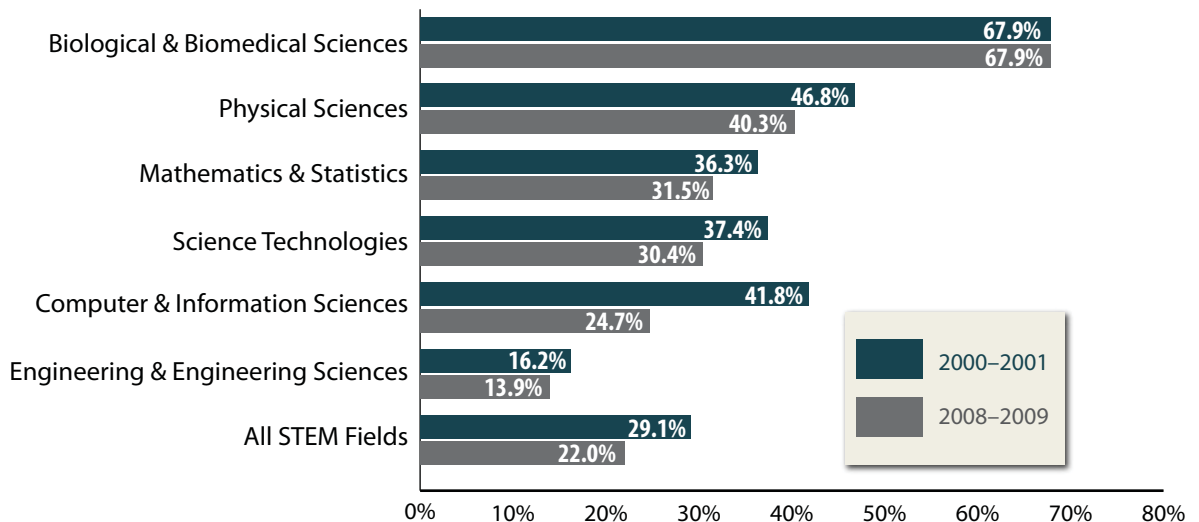
### POSTSECONDARY EDUCATION

At the postsecondary level, women are less likely to select a STEM major than a non-STEM major, and are more likely than their male counterparts to switch to a non-STEM major during their first year of college. With the 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 2009, only 22% of associate's degrees in STEM were earned by women. Even more troubling, the percentage of associate's degrees awarded to women in STEM fields has declined by 25% over the last eight years.<sup>13</sup> (See the chart below.)

The shifting educational experiences of women in college, including the presence of female graduate students, affect their persistence in STEM fields.<sup>14</sup> One review of student enrollment in STEM courses over a nine-year period (2001–2009) found that attrition varied greatly by field. In biology, for example, women made up 56% of introductory classes and 60% of fourth-semester classes. In contrast, the proportion of women taking computer science declined from 31% in the first semester to just 17% in the fourth semester (see the table on the next page, top). High attrition in many STEM fields signals a cultural problem that needs to be addressed through institutional and attitudinal changes as well as broader participation of women in STEM fields.

**Percentage of Associate's Degrees Awarded to Women by STEM Field, 2000–2001 and 2008–2009**



SOURCE: Institute for Women's Policy Research, *Increasing Opportunities for Low-Income Women and Student Parents in Science, Technology, Engineering, and Math at Community Colleges*, 2012. Data from the U.S. Department of Education, National Center for Education Statistics, *Postsecondary Awards in Science, Technology, Engineering, and Mathematics by State: 2001 and 2009*, April 2011. See <http://nces.ed.gov/pubs2011/2011226.pdf/>.

## Persistence of Women in Undergraduate STEM Courses, by Field

(% of female students per semester)

	BIOLOGY	CHEMISTRY	COMPUTER SCIENCE	GEOLOGY	MATH	PHYSICS	PSYCHOLOGY
INTRODUCTORY	56%	56%	31%	48%	48%	42%	61%
2ND SEMESTER	58%	58%	20%	38%	43%	44%	72%
3RD SEMESTER	58%	60%	18%	46%	38%	30%	76%
4TH SEMESTER	60%	58%	17%	47%	35%	31%	78%

NOTE: Figures reflect persistence among students in the 2001–2009 graduating classes. Women made up 51% of the total sample.

SOURCE: Kevin Rask, "Attrition in STEM Fields at a Liberal Arts College: The Importance of Grades and Pre-Collegiate Preferences" (2010). Working Papers. Paper 118. <http://digitalcommons.ilr.cornell.edu/workingpapers/118/>.

Women are earning more bachelor's degrees in some STEM fields in recent decades, most notably the biological and social sciences. Women's representation in these fields has climbed steadily since Title IX passed, and women now earn more than half of degrees granted in psychology. In other areas, however—including mathematics, physics, and engineering—progress has remained stagnant over the last decade, and in computer science, the percentage of women earning graduate and undergraduate degrees has actually declined in recent years.

At the postgraduate level the numbers are similar, with women earning slightly over half of

PhDs in the life sciences (including health and biological sciences) and 46% of PhDs in social sciences (including sociology and economics), but only 29% of PhDs in physical sciences (including astronomy, chemistry, physics, and earth sciences) and just over 20% of PhDs in computer science and engineering. (See the graph at the top of the next page.) Since the passage of Title IX in 1972, progress has been impressive across all fields in science, engineering, math, and medicine, with women's share of PhDs rising from just 11% in 1972 to 40% by 2006. As noted, however, this growth varies widely by field.

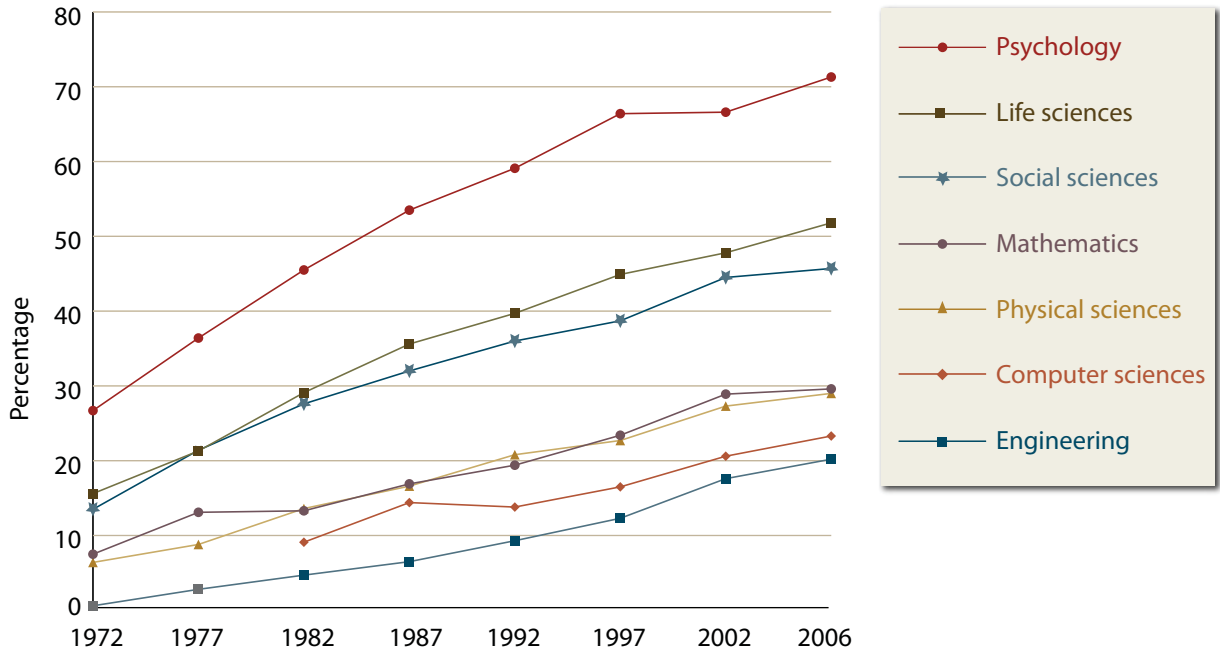
## Women in Academia

While the proportion of female assistant professors is somewhat consistent with the number of female PhDs in STEM, 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.<sup>15</sup> This gap reflects a tradition of institutional practices that make it difficult for women to advance through the ranks of academia.

Women have made some gains; their representation among all tenured or tenure-track

professor positions in STEM increased from 9.5% in 1979 to 28% in 2006. Yet women made up only 19% of full professors in these fields in 2006. As with other measures of achievement, attainment of full professor status varies by field, with women making up 33% of full professors in psychology and near or over a quarter in the social and life sciences, but only 5% in engineering and less than 9% in math and physical sciences. (See the graph at the bottom of the next page.) The percentage of female full professors in computer science has actually

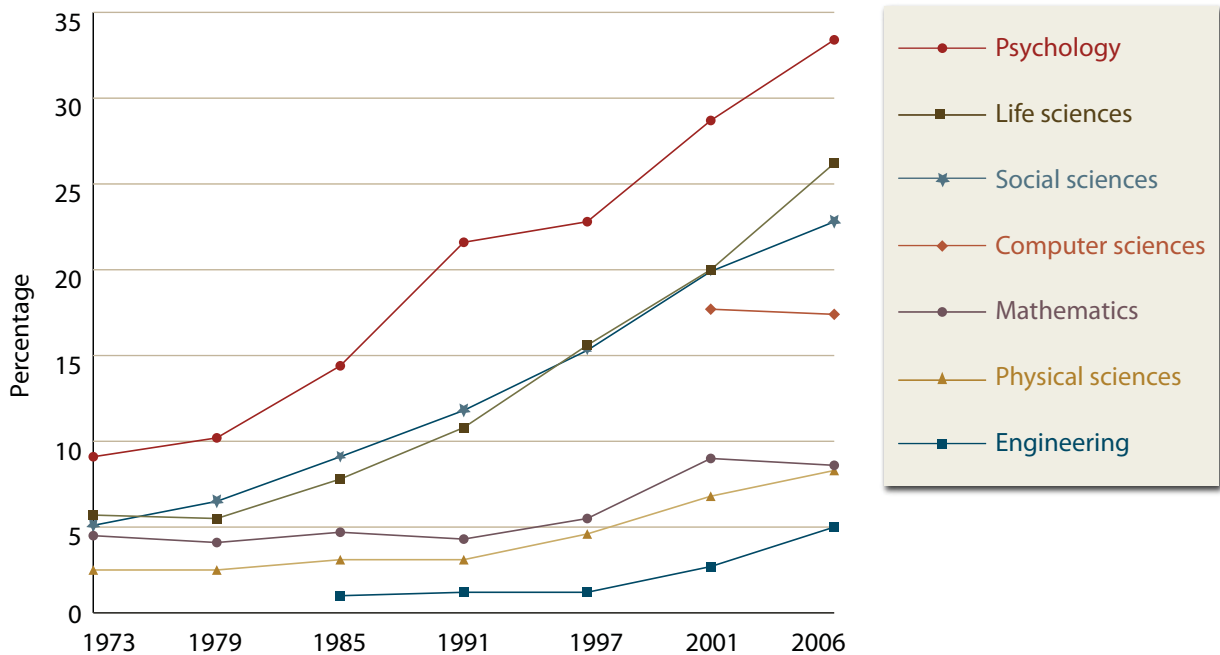
### Percentage of STEM Doctoral Degrees Awarded to Women by Field, 1972–2006



NOTE: Data on computer sciences was not collected until 1978.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, 1958–2006. Available at <http://www.nsf.gov/statistics/infbrief/nsf08308/#tab1/>.

### Women as a Percentage of Full Professors by Field of Doctorate, 1973–2006



NOTE: Missing data points indicate years when data were not collected or the sample size was too small for statistical significance. See the source for further notes on the data.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Doctoral Recipients, 1973–2006. <http://www.nsf.gov/statistics/infbrief/nsf08308/#tab5/>.

declined in recent years, from 23% in 1999 to 17% in 2006.

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, women continue to leak out of the academic pipeline 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. Without flexible options such as stop-the-tenure-clock, having children can be detrimental to a female faculty member's chances of promotion and tenure. Typically, faculty members who do not receive tenure within a certain amount of time after obtaining a PhD will be encouraged to leave the institution, although some institutions allow them to remain at the lower adjunct or assistant professor level. 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.

Women who marry, and especially those who have babies, are considerably less likely to advance than those who don't; those with babies are 29% less likely to enter a tenure-track

## KEY RESOURCES ON WOMEN AND STEM

### **Debunking Myths about Gender and Mathematics**

**Performance.** Jonathan M. Kane and Janet 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, 2009. Available at [http://odeo.hq.nasa.gov/documents/71900\\_HI-RES.8-4-09.pdf](http://odeo.hq.nasa.gov/documents/71900_HI-RES.8-4-09.pdf).

**Why So Few? Women in Science, Technology, Engineering, and Mathematics.** Catherine Hill, Christianne Corbett, and Andresse St. Rose. American Association of University Women (AAUW), 2010. Available at <http://www.aauw.org/learn/research/whysofew.cfm>.

**Where the Girls Are: The Facts about Gender Equity in Education.** Christianne Corbett, Catherine Hill, and Andresse St. Rose, AAUW, 2008. Available at <http://www.aauw.org/learn/research/upload/whereGirlsAre.pdf>.

position than those who don't, and married women are 20% less likely to enter a tenure-track position than their single counterparts. In contrast, having children does not seem to affect men's likelihood of attaining promotions or tenure. Overall, women are 25% less likely to attain full professorship than men.<sup>16</sup>

## STEM Careers

As in academia, the culture and expectations in STEM careers can make advancement in the workplace difficult for women, 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 24% of workers in STEM fields.<sup>17</sup>

The range of female participation in different STEM careers varies widely. According to the

NSF, 49% of the workforce in life and biological sciences is female, with the total number of women in these fields increasing by 50% over the past two decades. In contrast, the proportion of women working in engineering is still extremely low. Women made up 11% of engineers in 2009, up from 6% in 1983. Over the same time period, the percentage of female engineering technicians increased barely at all, from 18% to 19%.



made up 22% of health technicians in 2009, up from 16% in 1983. Similarly, men comprised 8% of registered nurses in 2009, up from just 4% in 1983.

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. As of 2007, that number had climbed to 26%.<sup>19</sup> This flexibility will give female employees more opportunity to stay in their STEM careers.

In mathematics and computer science, the proportion of women has actually declined, from 31% in 1983 to 25% in 2009.<sup>18</sup> 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.

At the same time, men have made gains in several areas within health care that have traditionally been dominated by women, a finding that highlights the benefits of equal opportunity in STEM for all workers. For example, men

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 incurs a major opportunity cost to 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.

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## Raising Awareness of Title IX and STEM

Those who look at the website of the U.S. Department of Education's Office for Civil Rights (OCR), the federal agency that regulates and monitors compliance with Title IX, might assume that Title IX protections from sex discrimination in education apply only to sexual harassment, pregnancy, and athletics.<sup>20</sup> In fact, Title IX also protects girls' and women's right to equality in STEM education, including equal access to academic and career and technical education courses; school-sponsored activities at the elementary, middle, high school, and college levels; and equal compensation, lab space, and institutional resources at research universities.

For example, if the use of a counseling test or other instrument results in a substantial underrepresentation of women in STEM courses, the school must take action to ensure that such disproportion is not the result of discrimination in the instrument, its application, or counseling practices in order to be in compliance with Title IX. Unfortunately, however, infractions often go unreported because many students—and even educators—do not realize that Title IX applies to STEM.

Raising awareness of existing protections is essential for ensuring that girls and women have equal access to education and careers in STEM. Often individuals who are responsible for Title IX are not aware of their responsi-



bilities as Title IX coordinators. Explicit and accessible instructions from the Department of Education on their duties and directives in relation to STEM education would allow schools to oversee compliance more effectively. On campuses and in national laboratories, advertisements 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 academic institutions to which they offer grants comply with Title IX, have an uneven track record in monitoring compliance. NASA has done over a dozen Title IX and STEM reviews since 2005. The agency has also published a comprehensive best practices report that can be used as a model for this type of activity, as well as other resources.<sup>21</sup> The Department of Energy has done half a dozen reviews, and is now implementing the NASA model. The NSF and other federal science and engineering agencies have been less rigorous. Greater pressure from granting agencies would help promote equity in STEM education, including in hiring, promotion, and tenure practices.

## NCWGE Recommendations

- The Department of Education guidelines for Title IX coordinators, which outline their responsibilities in ensuring equality in STEM education, should be broadly disseminated and publicized.
- Congress should direct federal, state, and local agencies to establish outreach and retention programs at the elementary, secondary, and postsecondary levels to engage girls and women in STEM activities, courses, and career development.
- Colleges and universities should establish standardized guidelines for tenure-track eligibility and offer a stop-the-clock option for women and men with small children.

“I love science and I like seeing how things work. I love to take things apart and see if I can get them back together. I always try to figure out how things work.”

—Preteen girl, Austin, TX

“I think [STEM work] can be very rewarding in the end when you get the result that you were looking for, or when you find a completely different result than what you were looking for; just knowing that you were able to start from a question or hypothesis and work to find this result that could possibly make a big difference in people’s lives.”

—Teenage girl, Indianapolis, IN

“Everyone knows about teaching as a career, but not everyone our age really thinks about engineering. They don’t know all that much about it.”

—Preteen girl, Wilmington, DE

“My dad always tells me this is where you have the potential...not arts, but engineering. If you have the support it makes you believe in it, even if nobody else does.”

—Teenage girl, Austin, TX

“I think some girls don’t want to do [STEM] because they don’t think it’s something girls should do. It’s a boy subject; they should stay far away from it.”

—Teenage girl, Indianapolis, IN

SOURCE: Girl Scout Research Institute, *Generation STEM: What Girls Say about Science, Technology, Engineering, and Math*, 2012. Available at [http://www.girlscouts.org/research/pdf/generation\\_stem\\_full\\_report.pdf](http://www.girlscouts.org/research/pdf/generation_stem_full_report.pdf).

- Federal grants should include interim technical support for researchers needing to take a leave of absence for care-giving purposes, and cover the cost of child care during travel that is related to the grant.
- Gender bias training is needed for awards selection committees and faculty department

chairs, professors, deans, and administrators at all levels of the STEM pipeline.

- All federal science agencies should conduct Title IX and STEM reviews 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.

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