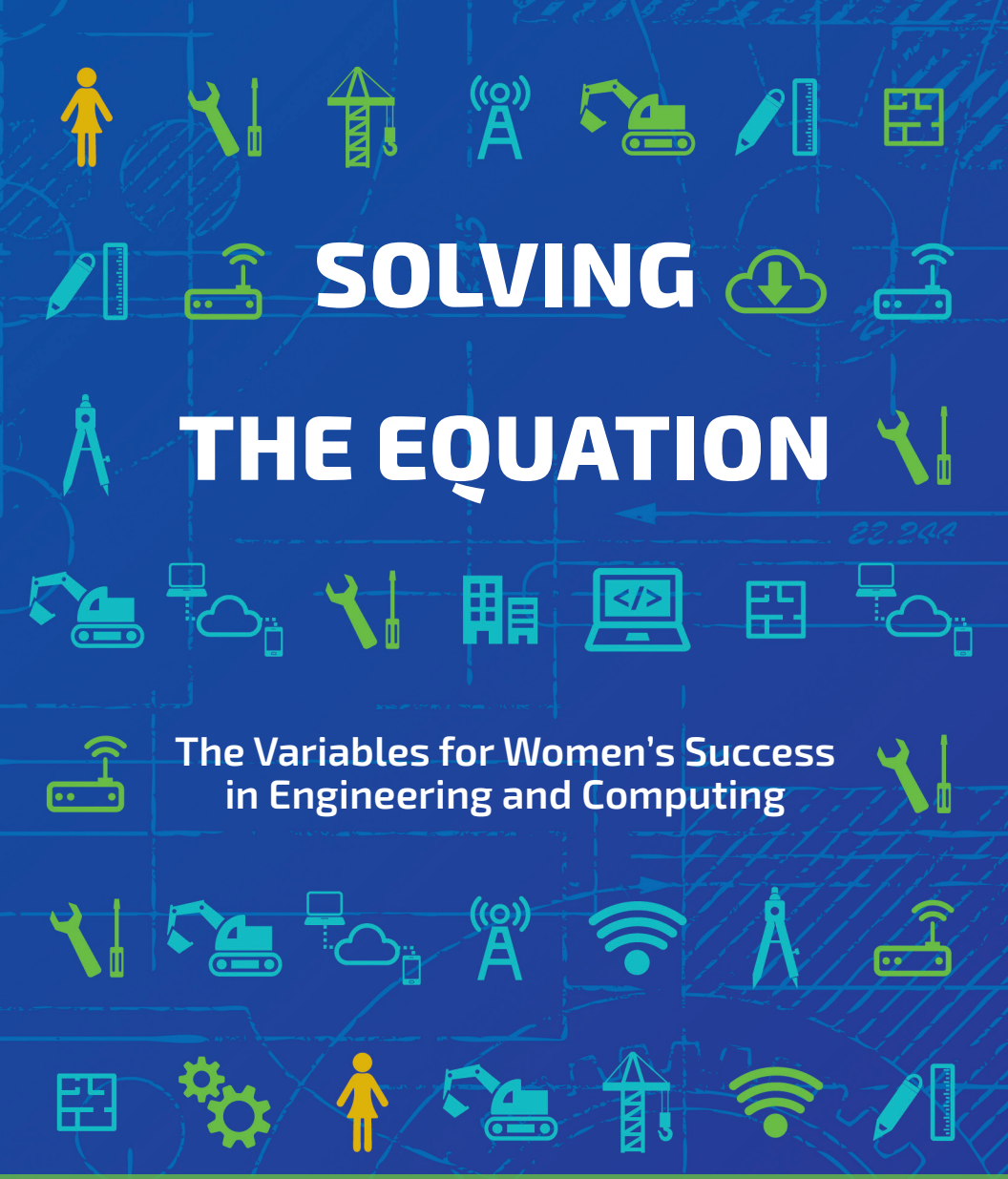

SOLVING THE EQUATION

The Variables for Women's Success in Engineering and Computing

EXECUTIVE SUMMARY

AAUW

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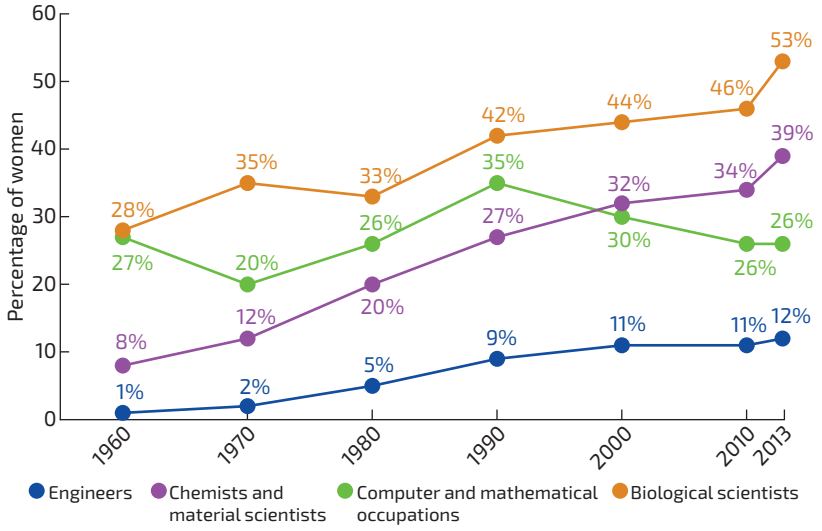
To download a free copy of the full report,
Solving the Equation: The Variables for Women's Success in Engineering and Computing, go to www.aauw.org/what-we-do/research.

More than ever before in history, girls are studying and excelling in science and mathematics. Yet the dramatic increase in girls' educational achievements in scientific and mathematical subjects has not been matched by similar increases in the representation of women working as engineers and computing professionals. Women made up just 26 percent of computing professionals in 2013, a substantially smaller portion than 25 years ago and about the same percentage as in 1960. In engineering, women are even less well represented, making up just 12 percent of working engineers in 2013.

The representation of women in engineering and computing occupations matters. Diversity in the workforce contributes to creativity, productivity, and innovation. Women's experiences—along with men's experiences—should inform and guide the direction of engineering and technical innovation. We simply can't afford to ignore the perspectives of half the population in future engineering and technical designs.

Advocates have long extolled the importance of advancing girls and women in science, technology, engineering, and mathematics (STEM).

WOMEN IN SELECTED STEM OCCUPATIONS, 1960–2013



Sources: AAUW analysis of data from U.S. Census Bureau (1960, 1970, 1980, 1990, 2000). Census of the Population; L. M. Frehill analysis of data from U.S. Department of Labor, Bureau of Labor Statistics (2014, 2011). Household data annual averages 2010 and 2013. Table 11. Employed persons by detailed occupation, sex, race, and Hispanic or Latino ethnicity. In Labor Force Statistics from the Current Population Survey, www.bls.gov/cps/aa2010/cpsaat11.pdf.

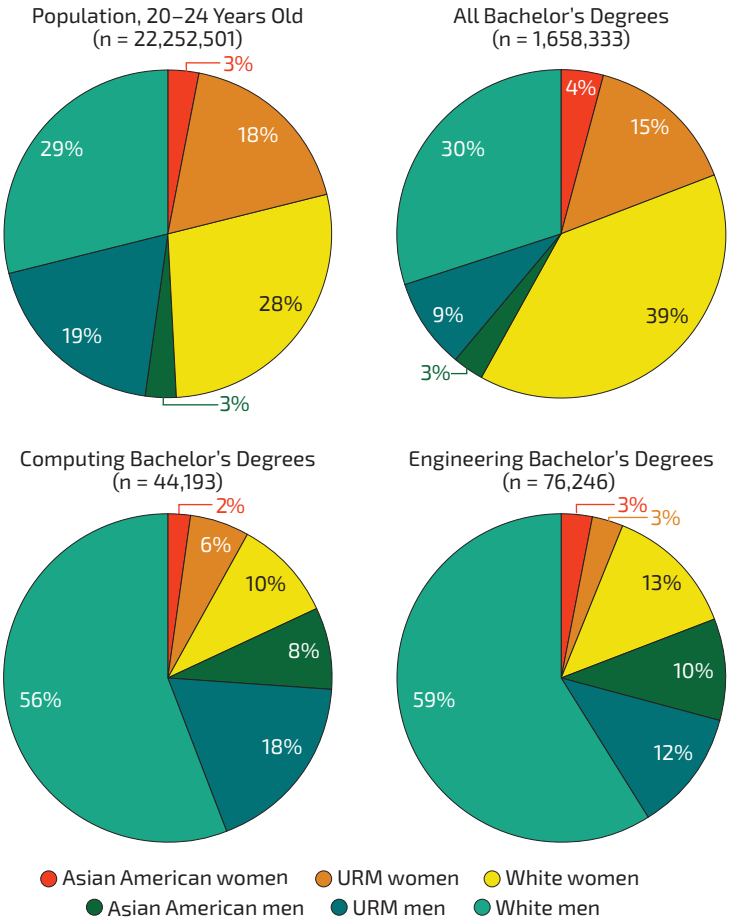
Engineering and computing stand out from the broader STEM category as the fields that offer the best opportunities for the greatest number of people. Accounting for more than 80 percent of the STEM workforce, engineering and computing occupations offer a higher return on investment and better prospects than jobs in other STEM fields offer. When women are not well represented in these fields, they lose out on these high-quality job opportunities.

Despite early similarities between girls and boys in math and science achievement, by high school, boys are more likely than girls to take the standardized exams most closely associated with the fields of engineering and computing. Among first-year college students, women are much less likely than men to say that they intend to major in engineering or computing. This disparity continues into the graduate level. In the workplace the discrepancy persists and in some cases worsens, as women leave engineering and computing jobs at higher rates than men do.

The issue of nonproportional representation in the number of engineering and computer science bachelor's degrees awarded is in large part an issue of women's underrepresentation, and some women of color are particularly underrepresented. Although black, Hispanic, American Indian, and Alaska Native women together made up 18 percent of the population ages 20 to 24 in 2013, they were awarded just 6 percent of computing and 3 percent of engineering bachelor's degrees conferred that year. In contrast, men from these demographic groups made up 19 percent of the population ages 20 to 24 and were awarded 18 percent of computing bachelor's degrees and 12 percent of engineering bachelor's degrees. Although men of some races and ethnicities are still underrepresented among those awarded degrees in these fields, particularly in engineering, men of every race and ethnicity are typically much closer to proportional representation than are their female counterparts.

Drawing on a large and diverse body of research, *Solving the Equation* highlights recent research that explores the factors underlying the underrepresentation of women in these fields, including stereotypes and biases, college curriculum, and workplace environment. The report argues for changes in the workplace and college environments as a necessary preamble to women's full participation in engineering and computing.

POPULATION AGES 20–24 AND BACHELOR'S DEGREES AWARDED IN SELECTED FIELDS, BY RACE/ETHNICITY AND GENDER, 2013



Notes: Charts include only U.S. citizens and permanent residents. Underrepresented minority (URM) includes American Indians and Alaska Natives, blacks, and Hispanics/Latinos.
Sources: L. M. Frehill analysis of National Science Foundation, National Center for Science and Engineering Statistics (2014). Integrated postsecondary education data system (IPEDS) completions survey by race, 2013; and U.S. Census Bureau (2014). Annual estimates of the resident population by sex, age, race, and Hispanic origin for the United States and states: April 1, 2010, to July 1, 2013.

COMBATING STEREOTYPES AND BIASES

We all hold gender biases, shaped by cultural stereotypes in the wider culture, that affect how we evaluate and treat one another. While explicit gender bias—that is, self-reported bias—is declining, implicit or unconscious gender bias remains widespread.

Several research findings shed light on the effects of stereotypes and gender bias as they relate to women in engineering and computing. One recent study found that scientists were more likely to choose a male candidate over an identical female candidate for a hypothetical job opening at a lab. Both female and male scientists also offered a higher salary to the male candidate. Another recent study found that potential employers systematically underestimated the mathematical performance of women compared with men, resulting in the hiring of lower-performing men over higher-performing women for mathematical work. Once objective past performance information was introduced, however, the employers made less biased hiring decisions. Bias is prevalent, but its effects can be diminished with more comprehensive information.

Hundreds of studies have documented the power of stereotypes to influence performance through a phenomenon known as "stereotype threat." Stereotype threat occurs when individuals fear that they will confirm a negative stereotype about a group to which they belong. One such group is "women." When negative stereotypes about women's mathematical abilities are brought to test-takers' attention during tests, women's performance drops. Stereotype threat has been theorized not only to influence women's mathematical performance but also to contribute to disengagement from fields in which women are negatively stereotyped, such as engineering and computing.

Much research has been done on how stereotype threat can affect academic performance, but researchers are only recently beginning to examine how stereotype threat affects women in the workplace. One recent finding in this area showed that the more often female STEM faculty had research-related conversations with their male colleagues, the less engaged they felt with their work. In contrast, the more social conversations female STEM faculty had with their male colleagues, the more engaged they reported being with their work. One possible explanation for this finding is that research-related conversations with male colleagues may generate stereotype threat for female scientists. Social conversations with male colleagues, on the other hand, may lessen the threat by increasing a feeling of belonging

in their work environment. Research suggests that stereotypes are activated for women more frequently when few women work in an organization. The presence of women at all levels of an organization has the potential to create environments that are less threatening for women.

Gender biases affect not only how we view and treat others but also how we view ourselves and what actions we take as a result. From early childhood we are exposed to stereotypes that guide our choices and behavior in powerful and often invisible ways, steering us toward certain careers and away from others. As early as first grade, children have already developed implicit biases associating math with boys. Studies suggest that girls who more strongly associate math with boys and men are less likely to perceive themselves as being interested in or skilled at math and less likely to spend time studying or engaging with math concepts.

A recent analysis of international differences in the composition of engineering and computing fields makes clear that the surrounding culture makes a difference in the gender makeup of these fields. Women in the United States earn approximately a fifth of all computing degrees, whereas in Malaysia women earn about half of all computing degrees. Similarly, in the United States women earn fewer than a fifth of engineering degrees. In Indonesia, however, women earn almost half of engineering degrees, and in a diverse group of countries women account for about a third of recent engineering graduates.

A recent study finds that most men who major in engineering and computing have relatively strong implicit biases associating men with science, whereas their female counterparts tend to have relatively weak science-male implicit biases. Engineering and computing workplaces have a wider gap in the gender-science bias among female and male employees relative to other fields. Female role models in engineering and computing can help shift implicit biases.

EMPHASIZING SOCIAL RELEVANCE

One factor that may contribute to girls and women choosing to pursue fields other than engineering and computing is the small but well-documented gender difference in desire to work with and help other people. Although communal goals are widely valued by both women and men, recent research finds that women are more likely than men to prioritize helping and working with other people over other career goals. Engineering and computing

jobs clearly can provide opportunities for fulfilling communal goals, but jobs in these fields are not generally viewed that way. Rather, engineering and computing are often thought of as solitary occupations that offer few opportunities for social contribution. The perception and, in some cases, the reality that engineering and computing occupations lack opportunities to work with and help others may in part explain the underrepresentation of women in these fields. Incorporating communal aspects—both in messaging and in substance—into engineering and computing work will likely increase the appeal of these fields to communally oriented people, many of whom are women.

CULTIVATING A SENSE OF BELONGING

Perhaps because of this combination of stereotypes, biases, and values, women often report that they don't feel as if they belong in engineering and computing fields. A recent study found that female engineering students were less likely than their male counterparts to feel a strong sense of fit with the idea of "being an engineer" as early as their first year in college. This more tenuous sense of fit with the professional role of an engineer was found to be associated with a greater likelihood of leaving the field. By emphasizing the wide variety of expertise necessary to be a successful engineer or computing professional—including less stereotypically masculine skills such as writing, communicating, and organizing—college engineering and computing programs can help young women see engineering and computing as fields in which they belong.

CHANGING THE ENVIRONMENT

Past decades have shown that simply trying to recruit girls and women into existing engineering and computing educational programs and workplaces has had limited success. Changing the environment in college and the workplace appears to be a prerequisite for fully integrating women into these fields.

COLLEGE

Harvey Mudd College is a prime example of how changing structures and environments can result in a dramatic increase in women's representation in computing. With leadership from the college president and college-wide

support, Harvey Mudd increased the percentage of women graduating from its computing program from 12 percent to approximately 40 percent in five years. This dramatic increase was accomplished through three major changes: revising the introductory computing course and splitting it into two levels divided by experience, providing research opportunities for undergraduates after their first year in college, and taking female students to the Grace Hopper Celebration of Women in Computing conference. These changes can be modified and applied at other colleges and universities. Taken together, they provide a roadmap for reversing the downward trend in women's representation among bachelor's degree recipients in computing.

THE WORKPLACE

While many studies have focused on factors contributing to women entering STEM occupations, far fewer have looked at the arguably equally important question of why women leave these fields, often after years of preparation, and what factors support them in staying. Recent research sheds light on why some women leave the engineering workforce and why others stay. Women who leave engineering are very similar to women who stay in engineering. The differences the researchers found were not in the women themselves but in their workplace environments.

Women who left engineering were less likely to have opportunities for training and development, support from co-workers or supervisors, and support for balancing work and nonwork roles than were women who stayed in the profession. Female engineers who were most satisfied with their jobs, in contrast, worked for organizations that provided clear paths for advancement, gave employees challenging assignments that helped develop and strengthen new skills, and valued and recognized employees' contributions. Women are making significant contributions to the fields of engineering and computing yet are still a distinct minority in these fields. Stereotypes and biases lie at the core of the challenges facing women in engineering and computing. Educational and workplace environments are dissuading women who might otherwise succeed in these fields. Expanding women's representation in engineering and computing will require concerted effort by employers, educational institutions, policy makers, and individuals to create environments that are truly welcoming for women.

WHAT CAN WE DO?

Underrepresentation of women in engineering and computing is a deeply rooted and complex social problem. But recent research and real-world initiatives have shown that there are ways to reduce gender bias, increase the perceived and actual social relevance of engineering and computing, and ultimately increase women's sense of belonging in these fields. Employers, educators, policy makers, and individuals can all take steps to improve women's representation in engineering and computing.

FOR EMPLOYERS

Employers are able to influence the representation of women in engineering and computing by changing the workplace climate and hiring and promotion practices.

MAINTAIN GOOD MANAGEMENT PRACTICES THAT ARE FAIR AND CONSISTENT AND THAT SUPPORT A HEALTHY WORK ENVIRONMENT

- Communicate clear responsibilities, goals, and paths toward advancement.
- Assign employees challenging projects that help them develop and strengthen new skills.
- Provide training and development opportunities for employees.
- Acknowledge and reward employees' contributions.
- Ensure that employees have manageable workloads and are not expected to routinely work excessive hours.
- Provide and encourage the use of work-life balance support such as on-site daycare, flexible work schedules, paid parental leave, and telecommuting.
- Provide opportunities for senior technical workers to mentor students or junior-level technical workers.
- Put in place anti-harassment policies such as that instituted by the Ada Initiative, adainitiative.org/what-we-do/conference-policies.
- Work to establish welcoming environments through inclusive workplace policies.

MANAGE AND PROMOTE DIVERSITY AND AFFIRMATIVE ACTION POLICIES

- Ensure that job advertisements, mission statements, and internal communications explicitly convey that your organization values diversity and gender inclusiveness.

- Assign responsibility for diversity to a diversity committee or full-time diversity staff.
- Involve men, especially white men, in gender diversity efforts.
- Conduct effective diversity training for employees.
- Monitor your progress in increasing women's representation in technical roles.

REDUCE THE NEGATIVE EFFECTS OF GENDER BIAS

- Make job qualifications clear and apply them evenly to all candidates.
- Base hiring decisions on objective past performance information when possible.
- Purposely remove gender information from evaluation scenarios when possible.
- Allow sufficient time to make in-depth and individualized evaluations of applicants.
- Ensure that hiring managers and other employees are aware of their own potential gender biases, such as by taking the gender-science Implicit Association Test at implicit.harvard.edu.
- Survey employees to assess the level of gender bias within your organization.
- Hold managers and recruiters accountable for their hiring and promotion decisions.

ENCOURAGE A SENSE OF BELONGING

- Create a welcoming environment for all employees.
- Encourage a supportive, friendly, and respectful environment.
- Root out uncivil and undermining behaviors.
- Increase the number of women at all levels of management.
- Provide opportunities for women to develop a support network of other technical women.
- Formally recognize necessary nontechnical work such as working well with others and mentoring—work that is not male-stereotyped—along with technical work.
- Be proactive and vocal about management's commitment to increasing the representation of technical women in your organization.

FACILITATE OPPORTUNITIES FOR EMPLOYEES TO WORK ON PROJECTS OR ISSUES THAT ARE SOCIALLY RELEVANT

- Pursue projects with clear social impacts whenever possible.
- Showcase how professionals' everyday work aligns with the societally beneficial outcomes that are the ultimate goals of engineering and technology.
- Establish social service days where employees volunteer in their communities.

FOR WOMEN WORKING IN ENGINEERING AND COMPUTING

Women engineering and computing professionals face challenges navigating stereotypes and gender biases in environments in which they are often the minority. They are also well placed to attract other women to these fields.

- Seek a support network. Some possibilities include participating in a Society of Women Engineers chapter, the Systers e-mail list (hosted by the Anita Borg Institute for Women and Technology), or a women-in-engineering or computing group on campus or at work.
- Prioritize working in jobs that allow you to work with others on socially relevant problems if you place a high value on communal goals.
- Seek opportunities to serve as a role model for girls and young women considering engineering and computing careers.
- Share with students at all levels how you work with and help people.

FOR MEN WORKING IN ENGINEERING AND COMPUTING

Because they make up the majority of workers in engineering and computing, men play important roles in creating the workplace climate and in recruiting and influencing prospective professionals. Importantly, the recommendations for increasing the representation of women in engineering and computing often benefit the men in these professions as well.

- Seek opportunities to serve as a role model for girls and young women considering engineering and computing.
- Refuse to participate on all-male conference panels. Encourage conference organizers to recruit at least one female panelist.
- Share with students at all levels how you work with and help people.

FOR EDUCATORS

Educators at all levels influence how students perceive the fields of engineering and computing, as well as how students view themselves.

- Spread the word that engineering skills and competencies are learned, not innate (in other words, cultivate a growth mindset). In engineering and computing classrooms, reduce the assumption that technical competence is innate by reinforcing the idea that successful engineers or computing professionals are willing to practice to develop their skills and persist through difficulties.
- Frame adversity as a common experience for everyone so that challenging coursework does not selectively signal to students that they do not belong in engineering or computing.
- Teach students about the effects of stereotype threat to lessen its effects.
- Give a broad range of people exposure to computing. Move away from the idea that certain people (often with strong programming skills) are cut out for computing while others are not.
- Highlight the broad applications of engineering and computing.
- Highlight the ways in which engineering and computing help people and provide opportunities for working with others.
- Provide opportunities for girls and young women to interact with women and men with whom they can identify in engineering and computing.
- Create welcoming environments for girls in math, science, engineering, and computing with gender-neutral decor; by endorsing a philosophy that explicitly values the social identity of women; and by increasing the representation and visibility of girls and women.
- Provide girls with opportunities to tinker and build confidence and interest in their design and programming abilities.

FOR COLLEGES AND UNIVERSITIES

Because most engineers and computing professionals are trained in their professions in institutions of higher education, colleges and universities have a special role to play in increasing the representation of women in engineering and computing.

ENGINEERING AND COMPUTING PROFESSORS

- Emphasize the social impact of engineering and computing work.
- Apply concepts that students are learning in class to community needs, incorporating project-based learning or service learning components into engineering or computing curricula.
- Apply engineering and computing to real-world problems.
- Emphasize ethical and social issues when teaching engineering and computing.
- Encourage a supportive environment in the classroom and in the program.
- Encourage and assist early contact between students and professionals.
- Emphasize the wide variety of expertise necessary to be successful as an engineer or computing professional.
- Highlight as early as possible the different facets that make up engineering and computing.

ENGINEERING PROFESSORS

- Expand examples beyond those that involve stereotypically male applications such as cars or rockets. The NSF-funded Engage project has a collection of gender-neutral Everyday Examples in Engineering that professors can use.
- Introduce students to experiences in the field early in undergraduate coursework to allow students to see the differences between textbook problems and the creativity and critical thinking necessary for actual engineering problem solving.

COMPUTING PROFESSORS

- Split classes by experience, providing students with less experience in computing with the time and environment they need to build their skills and interest.
- Question the idea that certain people (often with strong programming skills) are cut out for computing while others are not.
- Send female students (a mix of students interested in computing and those not considering computing as a major) to the Grace Hopper Celebration of Women in Computing or similar conferences. Taking even a few students can change the mindset of those students, who can then have a large effect on a program.

SOCIAL SCIENCE PROFESSORS

- Conduct research on how to counteract the effects of gender bias and the effects of diversity on outcomes.
- Conduct more research in field settings, in engineering and computing workplaces, and in classrooms.

ADMINISTRATORS

- Require researchers who receive federal funds to participate in bias training.
- Require all undergraduate students to take at least one computer science course, no matter what their major.
- Provide opportunities for female students in engineering and computing to develop a support network of other technical women.
- Offer and promote dual-degree programs for students interested in engineering or computing who also have strong interests in other fields.
- Engage in active public relations campaigns that make it clear to young women that engineers and technical professionals work cooperatively with others on problems that have impacts on the well-being of people, for example, by using the National Academy of Engineering's *Changing the Conversation* materials (2008).

FOR POLICY MAKERS

Policy makers can help improve the representation of women in engineering and computing through education programs and research funding, as well as by ensuring that federally funded programs comply with civil rights laws designed to tackle sex discrimination. Congress enacted Title IX to make sure that federal resources are not used to support discriminatory practices in education programs and to provide individual citizens effective protection against such bias. In addition, state and local governments can adopt and promote education and workplace policies that can narrow the achievement gap for girls and women in STEM.

FEDERAL GOVERNMENT

- The U.S. Department of Education should issue guidelines for Title IX coordinators that outline their responsibilities for ensuring equity in STEM education. The guidelines should cover concerns from elementary

and secondary education through postdoctoral studies and workforce training. These guidelines should be broadly disseminated and publicized.

- The executive branch should lead efforts to increase awareness, comprehensiveness, and transparency of federal agency Title IX compliance reviews. Such reviews, which all federal agencies should conduct, not only those in the Department of Education, are critical to leveraging change when recipients of federal funds are found lacking in the placement, advancement, and retention of women in STEM disciplines. Compliance reviews and mechanisms for enforcement of Title IX are available during pre-award reviews, post-award compliance reviews, and investigations of complaints.
- To comply with Title IX, federal agencies should ensure that educational institutions receiving grant funding or other financial assistance provide policies to maintain safe climates to prevent sexual harassment (including gender-based harassment and sexual assault) and nondiscriminatory policies for health insurance benefits and other services.
- Federal grant processes should allow for flexibility relative to academic engineers' and computer scientists' life events (such as birth or adoption of a child), and paid family leave and paid sick days should be encouraged.
- Congress should direct and provide adequate funding for federal, state, and local agencies to establish outreach and retention programs at the elementary, secondary, and postsecondary levels to engage women and girls in STEM activities, courses, and career development. For example, Congress should strengthen the gender-equity provisions of the America Competes Act reauthorization, which authorizes science and technology research programs for five years and contains provisions to support education and training aimed at addressing gender discrimination in the STEM fields.
- Congress should ensure that federal laws, such as the Carl D. Perkins Vocational and Technical Education Act, that fund and affect STEM education and workforce training also hold states and programs accountable for moving women and girls into training that is nontraditional by gender.
- Congress should include in STEM education laws provisions for support services, such as dependent care, transportation assistance, career counseling, tuition assistance, and other services that allow individuals to successfully complete training programs. In addition, federally funded career

guidance and counseling must be provided to all students and delivered in a fair manner that ensures that students are receiving unbiased information about high-skill, high-wage careers in nontraditional fields.
- *Rising above the Gathering Storm, Revisited* (National Academy of Sciences et al., 2010), commissioned by Congress, states that U.S. advantages in science and technology have begun to erode and discusses the need to improve math and science education. Unfortunately the report largely ignores the issue of girls and women in STEM fields. Congress should request a follow-up report on what effect increasing the number of women in STEM fields would have on enabling the United States to remain a leader in the global marketplace. This should illustrate the important contributions women can make to STEM fields and put weight behind efforts to increase opportunities for women and girls.
- Additional funding should be provided to better understand the underrepresentation of women in engineering and computing and to develop interventions that increase the representation of women in these fields.

STATE AND LOCAL GOVERNMENTS

- States should pass legislation to allow computing classes taught in secondary education to count toward graduation requirements.
- States should establish high-quality, uniform, and rigorous K–12 education standards, such as Common Core State Standards and Next Generation Science Standards or equally rigorous standards, to ensure that all students are taught to the same high expectations.
- State and local education agencies must be held accountable for improving the successful access to, and outcomes of women and girls in, career and technical education programs, especially in programs that are nontraditional for women and lead to high-skill, high-wage employment.
- All education funding should include support for teacher training to include recognition of implicit gender bias, awareness of stereotype threat, and ways to promote a growth mindset in students.
- All data regarding STEM study and workforce participation collected by state and federal governments should be disaggregated and cross-tabulated by gender and race.

FOR PARENTS

Parents, like educators, influence how girls perceive the fields of engineering and computing as well as their own abilities and can encourage their

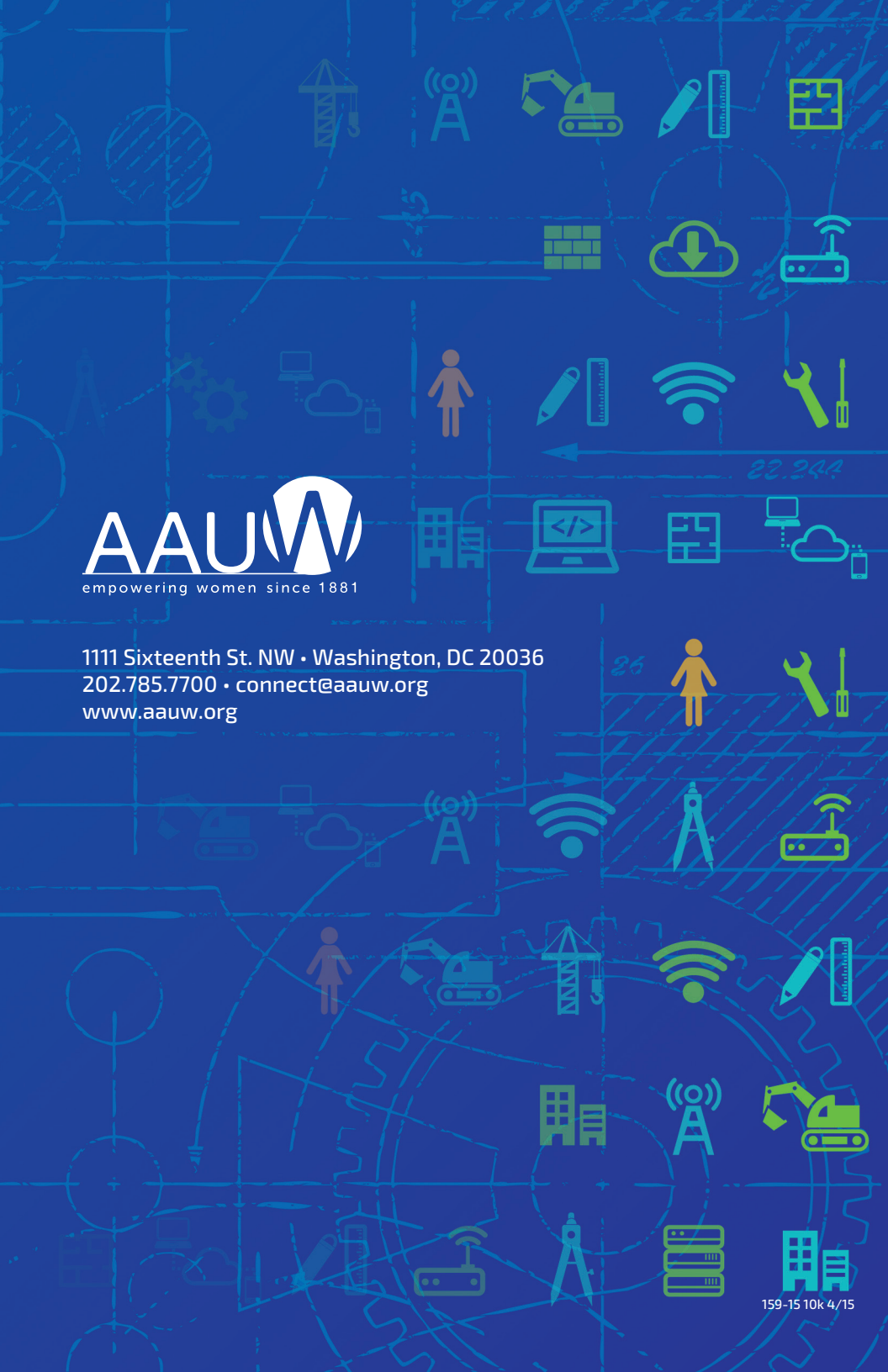
daughters to develop interest and confidence in these fields. Parents also play an important role in exposing their children both to the fields of engineering and computing generally and to women in these fields at early ages, when their implicit biases are forming.

- Cultivate a growth mindset in your children. Teach them that the brain is like a muscle that gets stronger and works better the more it is exercised. Teach them that passion, dedication, and self-improvement, not simply innate talent, are the roads to genius and contribution.
- Introduce your daughters to engineering and computing.
- Encourage your daughters to pursue mathematics and take calculus.
- Introduce your children to women and men with whom they can identify in engineering and computing fields.
- Question the idea that certain people (often with strong programming skills) are cut out for computing while others are not.
- Provide girls with opportunities to tinker, take things apart, and put them back together.
- Encourage your daughters to play and work with boys.
- Encourage your sons to play and work with girls.

FOR GIRLS

Girls should learn about engineering and computing so that they can make informed decisions about whether either of these fields is a good fit for their abilities and interests.

- Learn about the fields of engineering and computing. AAUW offers programs such as Tech Trek and Tech Savvy that provide opportunities for learning about these fields.
- Get to know women in engineering and computing.
- Tinker with things, take things apart, and put them back together.
- Cultivate a growth mindset. When you challenge yourself, work hard, and learn new things, your brain forms new connections, and over time you become smarter.
- Consider pursuing a dual-degree program in college, coupling a major in engineering or computing with a major in another field such as liberal arts or social science to allow in-depth pursuit of more than one interest.



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1111 Sixteenth St. NW • Washington, DC 20036
202.785.7700 • connect@aauw.org
www.aauw.org

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