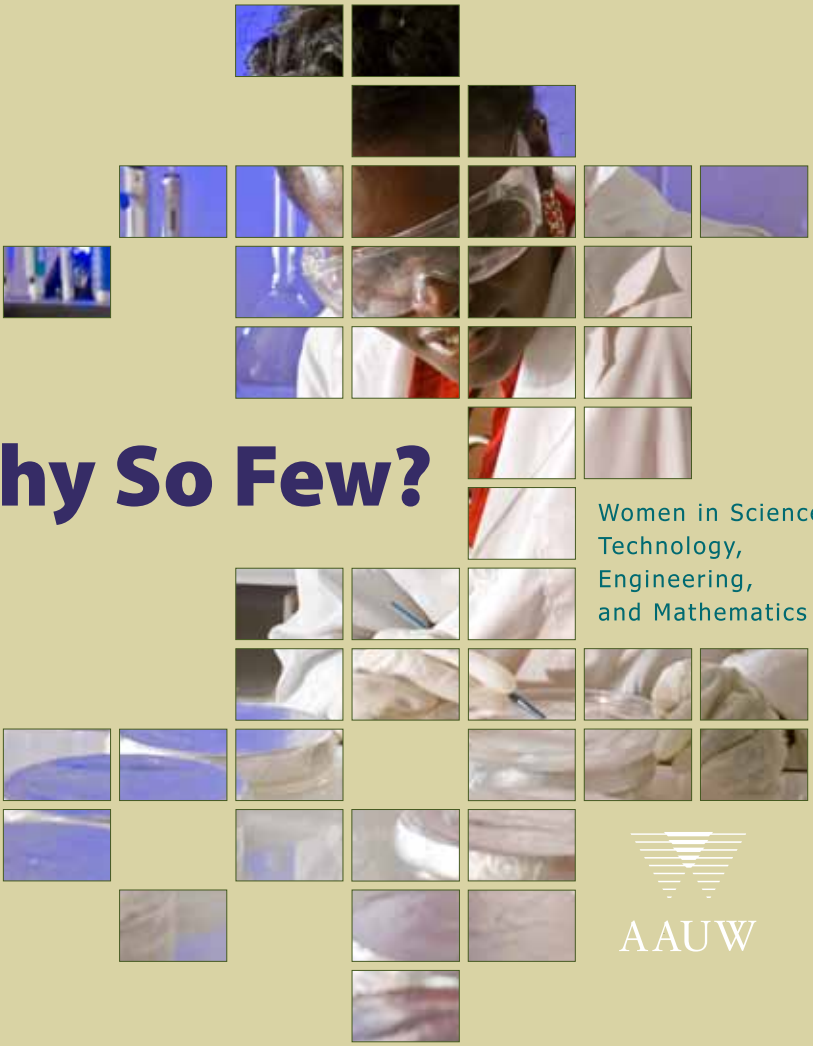


Why So Few?

Women in Science, Technology, Engineering, and Mathematics

AAUW

EXECUTIVE SUMMARY AND RECOMMENDATIONS

To download a free copy of the complete report, go to www.aauw.org/learn/research/whysofew.cfm.

Executive Summary

Women have made tremendous progress in education and the workplace during the past 50 years. Even in historically male fields such as business, law, and medicine, women have made impressive gains. In science, technology, engineering, and mathematics (STEM), however, women's progress has been slower, especially in engineering, computer science, and physics. In an era when women are increasingly prominent in medicine, law, and business, why are so few women becoming scientists and engineers?

Why So Few? Women in Science, Technology, Engineering, and Mathematics sheds light on the reasons behind women's underrepresentation in STEM. Drawing on a large and diverse body of peer-reviewed research, the report presents recent evidence on the social and environmental factors contributing to the disparity between the numbers of men and women in these fields. The findings are organized into three areas: social and environmental factors shaping girls' achievements and interest in math and science; the college environment; and the continuing importance of bias, often operating at an unconscious level, as an obstacle to women's success in science, technology, engineering, and mathematics.

GIRLS' ACHIEVEMENTS AND INTEREST IN MATH AND SCIENCE ARE SHAPED BY THE ENVIRONMENT AROUND THEM

The report demonstrates the effects of societal beliefs and the learning environment on girls' achievements and interest in science and math. One finding shows that girls who believe that intelligence can expand with experience and learning tend to do better on math tests; these girls are also more likely to say they want to continue to study math in the future. That is, believing in the potential for intellectual growth, in and of itself, improves outcomes. A "growth mindset" is helpful for all students, but it is particularly important for girls in mathematics, where negative stereotypes about girls' abilities persist. By encouraging a "growth mindset," teachers and parents can encourage girls' achievements and interest in math and science.

EXECUTIVE SUMMARY

Does the stereotype that boys are better than girls in math and science still affect girls today? Research profiled in this report shows that negative stereotypes about girls' abilities in math can indeed measurably lower girls' test performance. Researchers have also documented how stereotypes can lower girls' aspirations for science and engineering careers over time. When test administrators tell students that girls and boys are equally capable in math, however, the difference in performance essentially disappears, illustrating that changes in the learning environment can improve girls' achievements in math.

The issue of self-assessment, or how we view our own abilities, is another area where cultural factors have been found to limit girls' interest in mathematics and mathematically challenging careers. Research profiled in the report finds that girls assess their mathematical abilities lower than do boys with similar mathematical achievements. At the same time, girls hold themselves to a higher standard than boys do in subjects like math, believing that they have to be exceptional to succeed in "male" fields. One result of girls' lower self-assessment of their math ability—even in the face of good grades and test scores—and their higher standards for performance is that fewer girls than boys aspire to STEM careers. By emphasizing that girls and boys achieve equally well in math and science, parents and teachers can encourage girls to assess their skills more accurately.

One of the largest gender differences in cognitive abilities is found in the area of spatial skills, with boys and men consistently outperforming girls and women. Spatial skills are considered by many people to be important for success in engineering and other scientific fields. Research highlighted in this report, however, documents that individuals' spatial skills consistently improve dramatically in a short time with a simple training course. If girls grow up in an environment that cultivates their success in science and math with spatial skills training, they are more likely to develop their skills as well as their confidence and consider a future in a STEM field.

AT COLLEGES AND UNIVERSITIES, LITTLE CHANGES CAN MAKE A BIG DIFFERENCE IN ATTRACTING AND RETAINING WOMEN IN STEM

The foundation for a STEM career is laid early in life, but scientists and engineers are made in colleges and universities. Research profiled in this report demonstrates that small improvements by physics and computer science departments, such as providing a broader overview of the field in introductory courses, can add up to big gains in female student recruitment and retention. Likewise, colleges and universities can attract more women science and engineering faculty if they improve departmental culture to promote the integration of female faculty. Research described in this report provides evidence that women are less satisfied with the academic workplace and more likely to leave it earlier in their careers than are their male counterparts. College and university administrators can recruit and retain more women by implementing mentoring programs and effective work-life policies for all faculty.

BIAS, OFTEN UNCONSCIOUS, LIMITS WOMEN'S PROGRESS IN SCIENTIFIC AND ENGINEERING FIELDS

Most people associate science and math fields with "male" and humanities and arts fields with "female," according to research examined in this report. Implicit bias is common, even among individuals who actively reject these stereotypes. This bias not only affects individuals' attitudes toward others but may influence girls' and women's likelihood of cultivating their own interests in math and science as well. Taking the implicit bias test at https://implicit.harvard.edu can help people identify and understand their biases so that they can work to compensate for them.

EXECUTIVE SUMMARY

Not only are people more likely to associate math and science with men than with women, people often hold negative opinions of women in "masculine" positions, like scientists or engineers. Research profiled in this report shows that people judge women to be less competent than men in "male" jobs unless they are clearly successful in their work. When a woman is clearly competent in a "masculine" job, she is considered to be less likable. Because both likability and competence are needed for success in the workplace, women in STEM fields can find themselves in a double bind. If women and men in science and engineering know that this bias exists, they can work to interrupt the unconscious thought processes that lead to it. It may also help women specifically to know that if they encounter social disapproval in their role as a computer scientist or physicist, it is likely not personal and there are ways to counteract it.

The striking disparity between the numbers of men and women in science, technology, engineering, and mathematics has often been considered as evidence of biologically driven gender differences in abilities and interests. The classical formulation of this idea is that men "naturally" excel in mathematically demanding disciplines, whereas women "naturally" excel in fields using language skills. Recent gains in girls' mathematical achievement, however, demonstrate the importance of culture and learning environments in the cultivation of abilities and interests. To diversify the STEM fields we must take a hard look at the stereotypes and biases that still pervade our culture. Encouraging more girls and women to enter these vital fields will require careful attention to the environment in our classrooms and workplaces and throughout our culture.

Recommendations

Why are there so few women in science, technology, engineering, and mathematics? The answer lies in our perceptions and unconscious beliefs about gender in mathematics and science. Luckily, stereotypes, bias, and other cultural beliefs can change; often the very act of identifying a stereotype or bias begins the process of dismantling it. Through a review of the profiled case studies, AAUW has identified recommendations in three areas: cultivating girls' achievements, interest, and persistence in science and engineering, creating college environments that support women in science and engineering, and counteracting bias.

CULTIVATING GIRLS' ACHIEVEMENTS, INTEREST, AND PERSISTENCE IN SCIENCE AND ENGINEERING

Parents and educators can do a great deal to encourage girls' achievements and interest in math and science. Negative stereotypes about girls "innate" ability in mathematics and science persist and are harmful in measurable ways. Even a subtle reference to gender stereotypes has been shown to adversely affect girls' math test performance. Stereotypes also influence girls' self-assessments in math, which influence their interest in pursuing science, technology, engineering, and mathematics subjects and careers. Fortunately, research also shows that actively countering stereotypes can lead to improvements in girls' performance and interest in math and science.

- **Spread the word about girls' and women's achievements in math and science.**

  The more people hear about the achievements of women and girls in math and science, the harder it will be for them to believe the stereotype that boys and men are better than girls and women in these areas.

RECOMMENDATIONS

- **Expose girls to successful female role models in math and science.**

  Exposing girls to successful female role models can also help counter negative stereotypes in math and science, because girls see that people like them can be successful in these fields. Role models who describe their own experiences and challenges and how they overcame them can also help students see their struggles as a normal part of the learning process rather than as a signal of low ability.

- **Teach students about stereotype threat.**

  Research shows that the very existence of a negative stereotype (e.g., "boys are better than girls at mathematics") adversely affects the test performance of members of the negatively stereotyped group. This phenomenon is known as stereotype threat. However, research also shows that teaching students explicitly about stereotype threat can mitigate its effect. Teachers and college faculty are best suited to do this and, therefore, need to be educated about stereotype threat.

- **Teach girls that intellectual skills, including math and science skills, grow over time.**

  Interventions designed to promote a "growth mindset" (viewing intelligence as a changeable, malleable attribute that can be developed through effort over time) among students as opposed to a "fixed mindset" (viewing intelligence as an inborn, uncontrollable trait) benefit girls in math and science, because girls with a growth mindset are less affected by stereotype threat.

- **Encourage and help girls to develop their spatial skills.**

  One of the largest and most persistent gender differences in cognitive skills is in the area of spatial skills, where boys consistently outperform girls. Spatial skills are important for success in engineering, chemistry, and other STEM fields. Girls with well-developed spatial skills may

be more confident about their abilities and express greater interest in pursuing STEM subjects in elementary and middle school, and well-developed spatial skills also promote persistence in engineering majors in college. Provide girls with opportunities to develop their spatial skills by encouraging them to play with construction toys and 3-D computer games, sketch, and take shop, drafting, and mechanics.

- **Help girls recognize their career-relevant skills.**

  Girls are less likely than boys are to interpret their academic successes in math and science as an indication that they have the skills necessary to become successful engineers, physicists, or computer scientists. Encourage girls to see their success in high school math and science for what it is: not just a requirement for going to college but also an indication that they have the skills to succeed in a whole range of science and engineering professions.

- **Encourage high school girls to take calculus, physics, chemistry, computer science, and engineering classes when available.**

  Girls who take calculus in high school are three times more likely than girls who do not to major in a scientific or engineering field in college. Taking higher-level science and math classes in high school keeps a wider range of career options open to girls.

- **Teachers and professors can reduce reliance on stereotypes by making performance standards and expectations clear.**

  Research shows that the same letter or number grade on a math assignment or exam may signal something different to girls than it does to boys. Educators can help students better understand their grades by providing more detailed and specific feedback with recommendations for what students can do to improve, for instance. The more educators can reduce students' uncertainty about their performance, the less likely students will fall back on stereotypes to assess their abilities.

RECOMMENDATIONS

CREATING COLLEGE ENVIRONMENTS THAT SUPPORT WOMEN IN SCIENCE AND ENGINEERING

A foundation in science and math is laid early in school, but scientists and engineers are created in college. Although many young women graduate from high school well prepared to pursue a science or engineering major, relatively few women pursue majors in science, technology, engineering, or mathematics, and when they do, many capable women leave these majors before graduation. Even fewer women are present on science and engineering faculty. Research finds that small improvements in the culture of a department can have a positive effect on the recruitment and retention of female students. Likewise, departments that work to integrate female faculty and enhance a sense of community are also more likely to recruit and retain female faculty.

AAUW makes the following recommendations for creating college environments that support women in science and engineering.

To attract and retain more female students,

- **Actively recruit women into STEM majors.**

  Qualified women are less likely to have considered science and engineering majors than are their male peers. Colleges and universities should reach out to high school girls to inform them about the science and engineering majors they offer. For women who arrive at college underprepared or unsure of what they want to study, provide a pathway to major in a STEM field. Offer introductory courses that appeal to students with different levels of preparation or background in the major. This can be critical for identifying and recruiting talented STEM students from diverse backgrounds.

- **Send an inclusive message about who makes a good science or engineering student.**

  Admissions policies that require experience that will be taught in the curriculum (for example, requiring computer science major applicants to have significant prior computer programming experience) may weed out potentially successful students, especially girls. Revising admissions policies to send a more inclusive message about who can be successful in STEM majors can help departments recruit more qualified, capable women.

- **Emphasize real-life applications in early STEM courses.**

  Presenting the broad applications of science and engineering to students early in their college career builds students' interest and confidence. Early college courses emphasizing real-world applications of STEM work have been shown to increase the retention of women in STEM majors.

- **Teach professors about stereotype threat and the benefits of a growth mindset.**

  Research shows that professors can reduce stereotype threat in their classrooms and change students' mindsets from fixed to growth through the messages they send their students. Educate professors about stereotype threat, the benefits of a growth mindset, and how to create a growth-mindset environment in their classrooms by sending students the message that intellectual skills can be acquired and anyone who works hard can succeed.

- **Make performance standards and expectations clear in STEM courses.**

  Extremely low average test scores are common in many college science and engineering courses. Low scores increase uncertainty in all students,

but they have a more negative effect on students who already feel like they don't belong, as many women in STEM majors do. Clarifying what is expected can help students more accurately judge their performance. The more professors can reduce uncertainty about students' performance, the less students will fall back on stereotypes to assess themselves.

- **Take proactive steps to support women in STEM majors.**
  - Sponsor seminars, lunches, and social events to help integrate women into the department
  - Ensure that no student clique dominates or becomes the ideal way of "being" in a STEM major
  - Provide a welcoming student lounge open to all students to encourage interaction outside of class
  - Sponsor a "women in (STEM major)" group

- **Enforce Title IX in science, technology, engineering, and math.**

  Title IX is an important tool to help create equal opportunities and full access to STEM fields for women. Title IX compliance reviews by federal agencies ensure gender equity in STEM education.

To attract and retain female faculty,

- **Conduct departmental reviews to assess the climate for female faculty.**

  Although the climate within the department is important to both female and male faculty, it appears to be more important for female faculty and their overall satisfaction. When female faculty experience a negative climate, they report lower job satisfaction and are more likely to consider leaving their position.

- **Ensure mentoring for all faculty.**

  Both formal and informal mentoring of junior faculty are important, and the latter is crucial to support the integration of women into science and engineering departments.

- **Support faculty work-life balance.**

  Policies that effectively support work-life balance such as stop-tenure-clock policies and on-site, quality childcare are especially important to female faculty satisfaction.

COUNTERACTING BIAS

Bias against women—both implicit and explicit—still exists in science and engineering. Even individuals who actively reject gender stereotypes often hold unconscious biases about women in scientific and engineering fields. Women in "male" jobs like engineering can also face overt discrimination.

AAUW makes the following recommendations for counteracting bias:

- **Learn about your own implicit bias.**

  Take the Implicit Association Tests at https://implicit.harvard.edu to gain a better understanding of your own biases.

- **Keep your biases in mind.**

  Although implicit biases operate at an unconscious level, individuals can resolve to become more aware of how they make decisions and whether their implicit biases are at work in that process.

RECOMMENDATIONS

- **Take steps to correct for your biases.**

  Educators can look at the effect their biases have on their teaching, advising, and evaluation of students and can work to create an environment in the classroom that counters gender-science stereotypes. Parents can resolve to be more aware of messages they send their sons and daughters about their suitability for math and science.

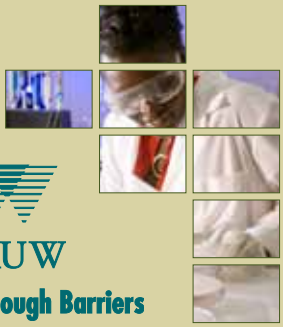
- **Raise awareness about bias against women in STEM fields.**

  If scientists and engineers are aware that gender bias is a reality in STEM fields, they can work to interrupt the unconscious thought processes that lead to bias. If women in particular in science and engineering occupations are aware that gender bias exists in these fields, it may allow them to fortify themselves. When they encounter dislike from their peers, it may be helpful to know that they are not alone. Despite how it feels, the social disapproval is not personal, and women can counteract it.

- **Create clear criteria for success and transparency.**

  When the criteria for evaluation are vague or no objective measures of performance exist, an individual's performance is likely to be ambiguous. When performance is ambiguous, people view women as less competent than men in STEM fields. Women and others facing bias are likely to do better in institutions with clear criteria for success, clear structures for evaluation, and transparency in the evaluation process.

Would you like to learn more about *Why So Few? Women in Science, Technology, Engineering, and Mathematics?* For a free electronic copy of our report, visit our website at www.aauw.org/learn/research/whysofew.cfm.



AAUW

Breaking through Barriers

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