Closing the Gender Gap

A new report examines key factors that may be keeping women from pursuing and succeeding in careers in science, technology, engineering, and math. ••• **BY JENNY JONES**

ALTHOUGH MORE WOMEN ARE WORKING in the fields of science, technology, engineering, and math (STEM) than ever before, they continue to be significantly outnumbered by their male counterparts. In 1960, for instance, the proportion of women in engineering was just 1 percent, and by 2000 that figure had risen to only about 11 percent. While it is unclear exactly why women remain a minority in STEM, a report from the American Association of University Women entitled *Why So Few? Women in Science, Technology, Engineering, and Mathematics* highlights eight recent research findings that point to particular social, cultural, educational, and self-confidence factors that may be hindering some women from pursuing careers in those fields.

The eight research findings that serve as the foundation for the report are categorized as follows: beliefs about intelligence; stereotypes; self-assessment; implicit bias; spatial visualization skills; the college student experience; university and college faculty; and workplace bias.

One such finding comes from Carol Dweck, Ph.D., a social and developmental psychologist at Stanford University who has studied the foundations of motivation for the past 40 years. Dweck's research suggests that one thing deterring some students, women perhaps in particular, from pursuing careers in STEM is their view of intelligence. Some students have a "growth mind-set," meaning that they view intelligence as a trait that can be nurtured over time through hard work, whereas others have a "fixed mind-set," viewing intelligence as an inherent and unchanging characteristic. Dweck has found that those with a fixed mind-set are more likely to lose confidence when encountering a challenge because they believe they are simply "not good" at a task and will never be good at it. Students with a growth mind-set, on the other hand, believe in the power of effort, and when confronted with a challenge their confidence actually grows because they believe they are becoming smarter as a result.

Dweck and her colleagues conducted several experiments to test their theory. One study involved more than 90 relatively low-achieving seventh graders who were split into two groups for 25 minutes each week. One group was taught that intelligence can be altered and that learning makes the brain stronger, just as a muscle is made stronger through physical training. That group was also taught that mistakes made in the course of learning are a valuable part of the process. The other group was taught study skills. Before the experiment, grades among all the students were declining on average. Within a few months, however, the students who were taught that intelligence can increase with hard work began to see an improvement in their grades. In contrast, the grades of the students in the control group continued to decline.

These findings are particularly relevant to women in STEM because those with a growth mind-set are more likely to believe that math and science skills, which are essential in most STEM careers, can improve with practice. "The more girls and women believe that they can learn what they need to be successful in STEM fields, the more likely they are to actually be successful in STEM fields," the report states.

Girls and women with a growth mind-set are also less likely to believe in the stereotypes that girls are not as good as boys in math and that men are better suited to scientific careers than are women. Research shows that beliefs in such stereotypes can diminish girls' and women's performance in math and science and can give rise to "stereotype threat," that is, concern over being viewed through the lens of a negative stereotype or a fear of doing something that would confirm that stereotype. "When girls and women believe they have a fixed amount of intelligence, they are more likely to believe in the stereotype, lose confidence, and disengage from STEM as a potential career when they encounter difficulties in their course work," the report states. Although stereotype threat first came to light in studies seeking to explain differences in the academic performance of African-American and Caucasian college students, many studies focusing on women have confirmed that the threat also exists with regard to gender.

In an interview with the American Association of University Women that was published in the report, Joshua Aronson, Ph.D., an associate professor of developmental, social, and educational psychology at New York University, says that stereotype threat can have implications beyond test performance. He explains that constant reinforcement of such stereotypes in school, the media, and at home can have significant psychological effects and can undermine aspirations in an area of interest through a process called disidentification, a defense erected to avoid the risk of being judged by a stereotype. Research suggests that stereotype threat and its consequences can be alleviated by teaching students about the phenomenon, reassuring them that the tests are gender neutral, and exposing them to female role models in math and science.

Negative stereotypes suggesting that men perform better at math and science can lead girls and women to question their own abilities. The report refers to research by Shelley Correll, Ph.D., a sociologist at Stanford University who has spent many years studying self-assessment and how it affects one's interest in math and science. Correll has found that among students with equivalent past achievement in math, boys tend to assess their mathematical abilities in a more favorable light than do girls. She also found that women tend to hold a higher standard of what constitutes success than do men, women believing they have to earn a score of at least 89 percent to be successful and men believing that a score of 79 percent or higher is sufficient. Self-assessment is important in STEM because if girls do not believe they have the ability to become scientists or engineers, they will probably choose other careers.

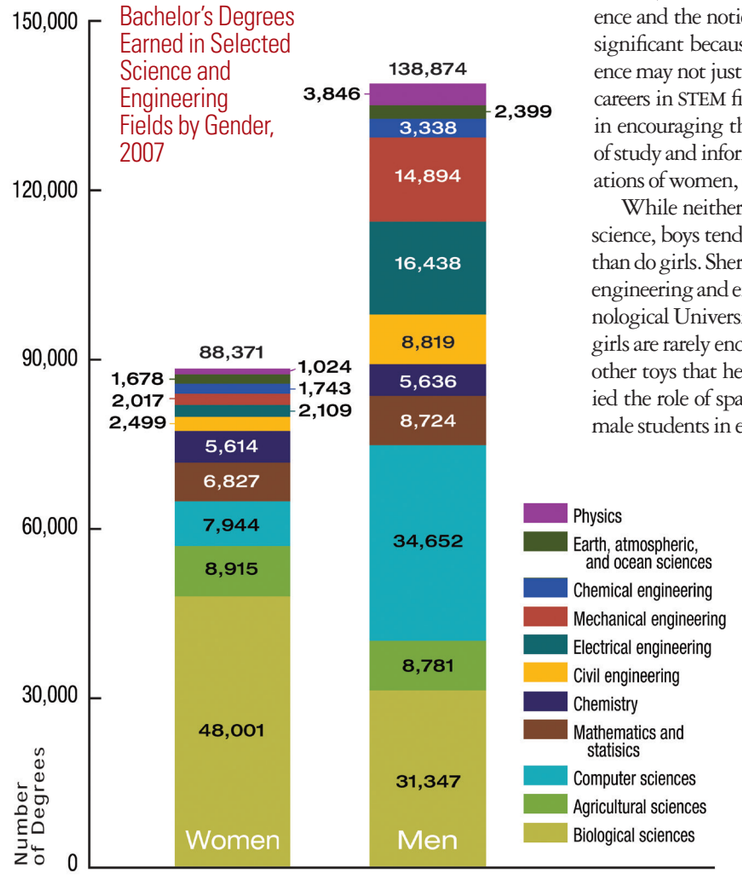
As part of her research, Correll analyzed the National Education Longitudinal Study of 1988, a survey of more than 16,000 students that was initially conducted when the students were in the eighth grade. A subsample of the original group of students was then surveyed three more times: when most of the students were sophomores, seniors, and two years beyond high school. Correll concentrated on survey questions that shed light on mathematical self-assessment, including those that asked students to rate how much they agreed with such statements as "Mathematics is one of my best subjects" and "I have always done well in math." She found that high school boys were more likely than their equally competent female peers to believe they were proficient in math.

Even people who say they do not believe in gender stereotypes regarding math and science may still hold those beliefs at an unconscious level, influencing assumptions about people and behavior. To test this theory, Mahzarin Banaji, Ph.D., a professor of social ethics at Harvard University, together with a team of professors from other institutions, developed what is called the implicit association test, which measures the association between two concepts to determine attitudes about particular groups. They also created the Project Implicit Web site (https://implicit.harvard.edu), where they have posted a variety of implicit association tests, including one that measures the extent to which the notion of male is associated with math and the notion of female is associated with the arts.

For the gender test, participants are asked to categorize 16 randomly ordered words, 8 denoting either male or female and 8 denoting either science or arts. In one round, participants are asked to indicate words denoting both male and science and both female and arts. In the second round, the pairings are switched. More than 500,000 people from around the world have taken the test, and more than 70 percent, both men and women, more readily associate the notion of male with science and the notion of female with arts. Such findings are significant because implicit biases against women in science may not just prevent girls and women from pursuing careers in STEM fields but also influence parents' decisions in encouraging their daughters to pursue a certain course of study and inform employers' hiring decisions and evaluations of women, the report states.

While neither gender is inherently better at math and science, boys tend to have better spatial visualization skills than do girls. Sheryl Sorby, Ph.D., a professor of mechanical engineering and engineering mechanics at Michigan Technological University, says the primary reason for this is that girls are rarely encouraged to play with blocks, LEGOs, and other toys that help develop spatial skills. Sorby has studied the role of spatial skills training in the retention of female students in engineering since the early 1990s and has found that students who cannot visualize how something is constructed are less likely to pursue a career in STEM. "If you think about civil engineering, [it] is extremely visual," said Sorby in an interview with *Civil Engineering*. As she put it, "You can't design a bridge if you can't imagine what the abutment would look like coming up to the bridge deck. You can't design a water system unless you can visualize how all the pipes fit together and how the water flows. Civil engineering is highly visual, and if you can't visualize I think you're handicapped in the field."

Sorby teamed up with Beverly



NATIONAL SCIENCE FOUNDATION, DIVISION OF SCIENCE RESOURCES STATISTICS. 2009. WOMEN, MINORITIES, AND PERSONS WITH DISABILITIES IN SCIENCE AND ENGINEERING: 2009 (NSF 09-305) (ARLINGTON, VA). TABLES C-4 AND C-5.

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Baartmans, a math educator at Michigan Technological University, to study spatial skills among women in engineering. The duo administered the Purdue Spatial Visualization Test: Rotations (PSVT:R), along with a background questionnaire, to 535 first-year engineering students at Michigan Technological University. An analysis of students' test and questionnaire responses showed that previous design experience—including drafting, mechanical drawing, and art, as well as having played with such toys as Erector Sets and Lincoln Logs as a child—improved a student's chance of doing well on the test. Women were more than three times as likely as their male peers to fail the test; 39 percent of women failed, compared with 12 percent of men.

With funding from the National Science Foundation, Sorby and Baartmans developed a course in spatial visualization for first-year engineering students who had poorly developed spatial skills. The goal of the course was to increase the retention of women in engineering by teaching basic spatial visualization skills, and the course covered isometric and orthographic sketching, the rotation and reflection of objects, and cross sections of solids. At the end of the course, students took the PSVT:R again. The scores improved from an average of 52 percent before the course to 82 percent after it.

Each year since the course's inception, in 1993, students who have taken it have improved their performance on the PSVT:R by more than 20 percentage points. Sorby also found that 77 percent of the women who initially failed the test and who took the spatial visualization course between 1993 and 1998 were still enrolled in or had graduated from Michigan Technological University's College of Engineering. Among the women who initially failed the test and did not take the course, however, only 48 percent were still enrolled in or had graduated from the College of Engineering. The course is now required for all engineering students at the university who fail the PSVT:R.

While many women have the abilities necessary to succeed in STEM majors, the milieu of the academic departments at many universities—including the expectations, assumptions, and values that guide the actions of professors, staff members, and students—may make women feel unwelcome. The report looks at two research studies that support the theory that certain improvements to science and engineering departments could help retain women in STEM.

Jane Margolis, a senior researcher at the University of California at Los Angeles's Graduate School of Education and Information Studies, and Allan Fisher, a former faculty member and associate dean for undergraduate computer science education at Carnegie Mellon University, conducted a four-year study of women in Carnegie Mellon's School of Computer Science to better understand why so few women go into computer science. Between 1995 and 1999 they interviewed more than 100 students numerous times, beginning with their first semester in the computer science department and concluding when the students graduated or left the major. They also interviewed faculty members, examined student journals, and observed classes. At the beginning of the study, women constituted only 7 percent of undergraduate computer science majors and were almost twice as likely as men to leave the major.

Margolis and Fisher found that men in computer science often recounted having an intense interest in the subject at an early age, while women reported that their interest formed gradually. They also found that computer science is culturally regarded as a male profession and that there is a perceived "right way" to work with computers, which often makes women feel like outsiders in the profession. Women who feel as though they don't belong in computer science are more likely to report lower confidence in the field than is the case with their male counterparts, research shows.

In addition to the Carnegie Mellon study, the report includes research by Barbara Whitten, Ph.D., a professor of physics and women's studies at Colorado College, who collaborated with a team of researchers to examine what keeps women in undergraduate physics departments. In 2002 the team visited nine undergraduate physics departments in the United States. In five of them, women made up 40 percent of the graduates, while in the other four the number of women graduates was closer to 20 percent, the national average at the time. The researchers spent two days in each department and found that the most successful departments supported activities that created a sense of inclusiveness for students of varying backgrounds. Those departments often had physics lounges and sponsored social events that enabled students and faculty members to interact and get to know one another.

Improving the milieu of academic departments may not only help retain female students; it may also pay dividends when it comes to recruiting and retaining female faculty members. At present, some universities' STEM departments have only one or two women on the faculty. In an effort to improve the academic environment for junior faculty members, particularly women, Cathy Trower, a research associate at Harvard University's Graduate School of Education, cofounded the Collaborative on Academic Careers in Higher Education in 2002. The program includes more than 130 colleges and universities that participate in the Tenure-Track Faculty Job Satisfaction Survey, which is administered annually to all full-time tenure-track faculty members at participating institutions. The survey asks junior faculty members to express their level of satisfaction regarding promotion, the nature of their work, policies and practices, and the general milieu and level of collegiality on their campuses.

The survey results have shown that female STEM faculty members are less satisfied than male faculty members with how well they "fit," or belong, in their departments. The women report having fewer opportunities than do their male counterparts to work with senior faculty members, and they say they are often excluded from informal social gatherings and more formal events. The women also report having fewer mentors available than do their male colleagues, and they are less likely than the men to agree that their institutions support having and raising a child while on a tenure track.

The academic setting is not the only place where women in STEM experience hurdles because of their gender. Madeline Heilman, Ph.D., an organizational psychologist at New York University, has found that women in "masculine" fields, including most STEM fields, are considered either likable or competent but not both. In one experiment, Heilman and her colleagues recruited 48 undergraduates from the psychology department of a large northeastern university. They asked the students to rate the competence and likability of three employees—a man, a woman, and a "dummy man"—in a job typically held by a man: assistant vice president of an aircraft company. The dummy man was included so that it would not be obvious to the participants that the purpose of the experiment was to examine differences in evaluation based on gender, the report states. The participants' rating of the dummy man was not analyzed. The participants received packets that described the job responsibilities, which included training and supervising junior executives, breaking into new markets, keeping abreast of industry trends, and finding new clients. The stereotypical nature of the work was communicated via the products involved, including engine assemblies, fuel tanks, and other aircraft equipment and parts.

The 48 undergraduates were then split into two groups. One group was told that the men and woman were about to undergo their annual performance reviews, so their performance was unclear. The other was told that the men and woman were clearly successful and had been named top performers by the organization. When performance was made explicit, participants saw the man and the woman as being equally competent. When performance was not clear, however, the participants rated the woman as being significantly less competent than the man. Moreover, when performance was not known, the participants rated the man and the woman as equally likable. But when performance was clearly stated, participants overwhelmingly indicated that the man was more likable than the woman. The successful woman was also rated as less diplomatic and less congenial than the successful man, while the woman was rated significantly more diplomatic and more congenial when success was ambiguous.

Based on the research findings, *Why So Few? Women in Science, Technology, Engineering, and Mathematics* provides a number of recommendations for engaging more women in STEM, including cultivating girls' interest in science and engineering by exposing both girls and boys to female role models in STEM careers, teaching girls that intellectual skills can be developed, creating college environments that support women in science and engineering, and raising public awareness of bias against women in STEM fields. The report stresses that because scientists and engineers are working to solve some of the world's most complex problems, it is of the utmost importance that all groups of people, including women, be represented in the workforce.

When women are not properly represented in STEM, their needs and desires often go unmet. Such was the case when a group of predominantly male engineers developed the first automobile air bags based solely on the size of adult male bodies. This resulted in avoidable deaths of women and children, according to the book *Unlocking the Clubhouse: Women in Computing* (Cambridge, Massachusetts: MIT Press, 2001), by Margolis and Fisher. "If we don't include women, if we don't include African-Americans, if we don't include Hispanics, if we don't include a wide diversity of people [in STEM fields], then we're shutting ourselves out of more than half of the available population," says Barbara Bogue, Ph.D., an associate professor of engineering science and mechanics at Pennsylvania State University and a former director of the Women in Engineering Program there. Bogue, who served on the report's advisory committee, sums it up aptly: "We need to make sure that the ones who have the interest have equal access to STEM studies and careers."

To read the full report, visit www.aauw.org/learn/research/whysofew.cfm. **CE**


Jones

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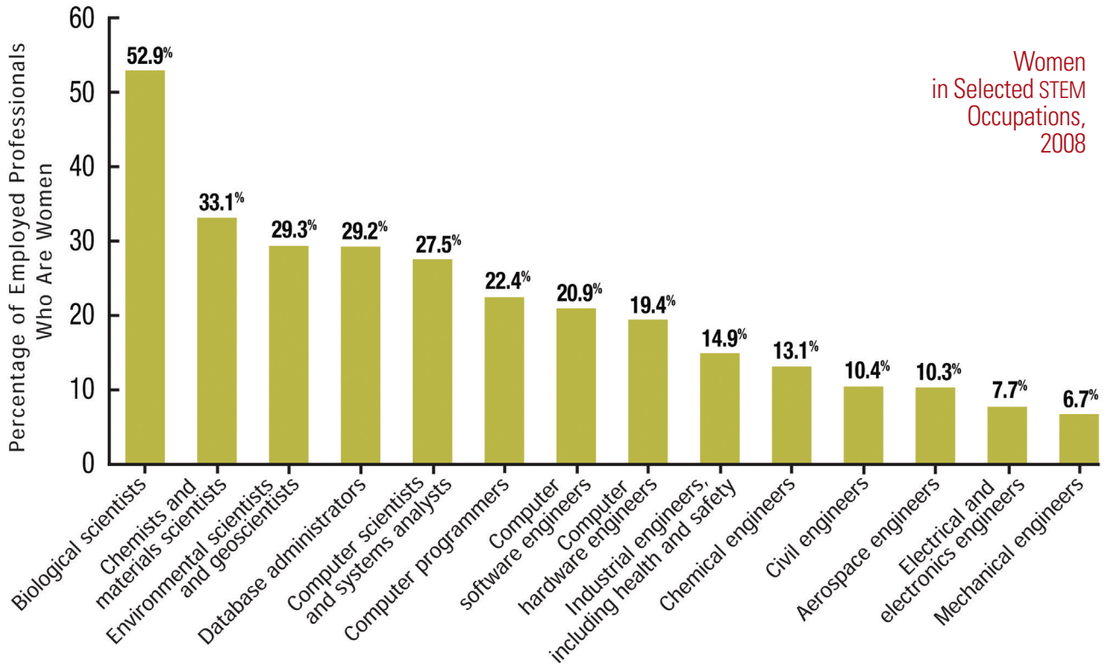

NOTE: OCCUPATIONS ARE SELF-REPORTED. U.S. DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS, 2009. WOMEN IN THE LABOR FORCE: A DATABOOK (REPORT 1016) (WASHINGTON, DC), TABLE 11.

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