Women in Science, Technology, Engineering and Math (STEM)

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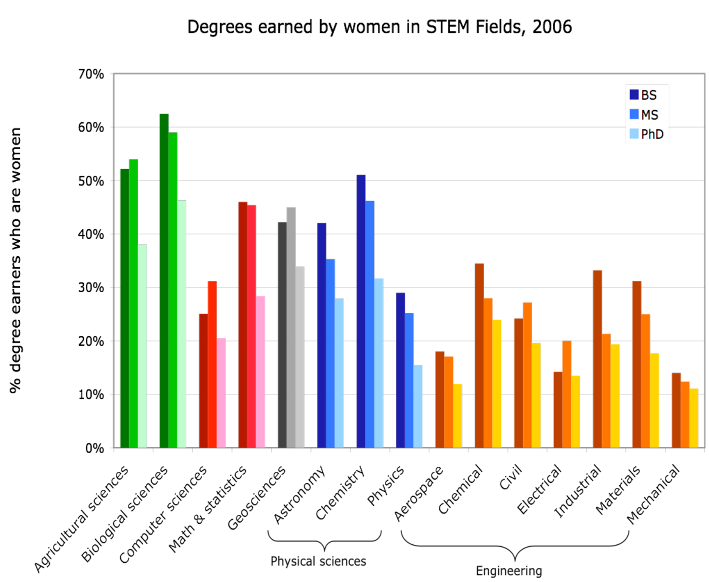
The representation of US women and girls in science, technology, engineering, and mathematics (STEM) fields has risen dramatically in recent decades (NSF 2006c). Yet women are still concentrated in certain disciplines, and most professions continue to be sex-segregated (CPST 2004). Equitable representation would offer women equal access to well-paid, high-status STEM careers and add new perspectives to scientific and technical innovation.

EDUCATION

In the US, gender differences in STEM representation emerge early. Two-thirds of young children—boys and girls alike—say they like science, but gender differences in attitudes and interest surface in middle school (AAUW 1992; NSF 2007b). Girls now take as many high school science courses as boys, and perform as well (AAUW 2004), but many girls who take advanced science courses in high school do not continue to study science in college. Disparities persist despite women's interest in STEM fields. For example, African-American women have been shown to have higher levels of interest in science than their white counterparts (Hanson 2004). College women's representation varies by field and by ethnicity or race: women make up over half of all undergraduate degree-earners in life science, but one-fourth of those in physics (NSF 2007a). In technology, early gender inequities in computer interest, use, and skills are well documented (AAUW 2000; Margolis & Fisher 2002) and the proportion of women among those pursuing computer science degrees has *declined* since the mid-1980s (Spertus 2004). In engineering, trends have flattened, and are highly variable within sub-fields: women earn 35% of chemical engineering degrees, but only 14% in electrical engineering (NSF 2007a).



At higher levels of STEM education, the percentage of women continues to decline; this is the so-called "leaky pipeline." For example, though women earn nearly half of mathematics bachelors' degrees, they earn only 27% of doctoral degrees. Women are well represented among life science PhDs, approaching equity in agriculture, chemistry and geoscience, and more strongly under-represented in physics, computer science, and engineering (NSF 2007a). Across all STEM fields, the proportion of women of color is small, and drops at each level of degree attainment (NSF 2007a, CPST 2007).

Figure from data in NSF 2007a.

EMPLOYMENT

Men outnumber women (73% vs. 27% overall) in all sectors of employment for science and engineering (S&E) (NSF 2007a). Gaps between men and women are larger in business and industry (79% men vs. 21% women) and in federal government jobs (73% vs. 27%). Women do outnumber men in educational institutions such as K-12 schools, 2-year colleges, junior colleges, and technical institutes, where they have lower salaries and lower prestige. In the last 25 years, the share of S&E occupations has more than doubled for Black men and women (2.6% to 6.9%) and for all women (12% to 25%), yet disparities by race and ethnicity remain (NSF 2007a). White women comprise some 20% of the 4.9 million S&E workers, Asian-American women 4%, Black women 2%, Hispanic women 1.2%, and American Indian/Alaskan Native women just 0.1%. Because they are represented above their level in the general population, Asians are not considered an "underrepresented" minority in S&E. In general, across disciplines and sectors of employment, whites outnumber all minorities by almost three to one.

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Academic employment is an area of particular concern because faculty educate and influence students. Representation of women in STEM academic careers has improved consistently, but slowly, and disparately across disciplines. Some of this is explained by the age structure in academia (Long 2001)—faculty careers are long and do not turn over rapidly—and the gender gap is closing in many fields at the assistant professor rank. However, at any given career stage, men in STEM are more likely to hold a higher rank than women. Without aggressive changes to recruitment and retention, the proportion of women among faculty cannot reach parity with the hiring pool (Marschke et al. 2007). The data show that women are concentrated in lower-status positions—including early tenure-track ranks, non-tenure-track academic positions, and lower-status institutions—and that inequities are related to both gender and race/ethnicity (NSF 2007a, Nelson 2004).

Women as percentage of all faculty, by ethnicity (n=385,200 faculty total)

	All faculty	Full professors	Associate professors	Assistant professors
All women	31.7%	20.6%	32.9%	39.4%
White women	23.9%	17.7%	25.3%	28.7%
Asian women	3.9%	0.9%	2.3%	5.2%
Black women	2.3%	1.3%	4.3%	2.4%
Hispanic women	1.3%	0.6%	1.0%	2.2%
American Indian & Alaska Native women	0.2%	0.1%	0.1%	0.4%

Data adapted from NSF 2007a, Table H-25, http://www.nsf.gov/statistics/wmpd/employ.htm

AROUND THE WORLD

Many of the issues for US women in STEM are also seen in other countries. In a study of Swedish postdoctoral fellowships, women had to score five times higher in the merit review process to be rated the same as men (Wennerås & Wold 1997). In Italy, women researchers in national labs advance at half the rate of their male peers (DeWandre 2002). In the UK, women have accounted for half of biology graduates for 30 years, yet women hold only 9% of full professorships (DeWandre 2002).

Yet important differences also exist among countries. For example, Turkey and Greece graduate twice as many BS and PhD physicists as the US. Germany's neighbor France produces nearly three times as many physicists as does Germany. France also provides state-supported child care for two-career families, while Germany does not (Ivie & Ray 2005). The international evidence suggests that underrepresentation is mainly a cultural phenomenon, rather than due to innate differences (Linn 2007), and that policies can affect workforce diversity.

WHY SO FEW?

Researchers offer several explanations for the low numbers of women at all stages of STEM careers:

- The *classroom climate* for girls in school classrooms and for women students and faculty in university departments has been classically described as "chilly" (Hall & Sandler 1982). Girls and women are treated differently than men in both subtle and overt ways. For example, everyday ways of conducting classroom discussions can exacerbate inequities when boys are given more attention and praise by the teacher.
- A *dearth of role models* is another contributing factor to the underrepresentation of women in science. Women students look to faculty as role models for balancing career and family, and if career demands are seen as excessive, may leave their department in higher numbers than men (Ferreira 2003). Women scientists benefit from role models and mentors who are cognizant of the differential experiences of women and men in the sciences (Etzkowitz et al. 2000).
- *Poor preparation and lack of encouragement in STEM subjects* in school also contributes to a lack of women in STEM fields. Women undergraduates enter their majors highly qualified and competent, yet experience a drop in confidence in the first year of their science and engineering studies (Brainard & Carlin 2001; Seymour

1995). The primary reasons that women give for leaving are a loss of interest in the field, discouragement at academic difficulties, and poor teaching (Seymour & Hewitt 1997). Girls may also be less prepared than boys in science and math during their high school years, lagging behind their male peers in some measures of science achievement and in confidence in their scientific abilities (AAUW 1992).

- *A lack of "critical mass" of women* in a department may lead to dissatisfaction and greater attrition of women scientists (Dresselhaus et al. 1995; Ferreira 2003). The theory of critical mass asserts that as representation of women increases, so will their access to important resources and social networks. However, Etzkowitz et al. (2000) highlight the paradox of "critical mass" by arguing that the organization and culture of academic science must change in order to encourage more women to enter the profession. "Critical mass" is meaningful only if the organization is democratic and inclusive.
- *Bias and discrimination in hiring and advancement of women* leads to slower advancement of women in science, particularly in academic science. Valian (1998) posits an important role for gender schemas, people's mental constructions of categories and their beliefs about those categories. People create normative beliefs and stereotypes about gender that affect the way they perceive the behavior and attributes of women and men. For example, women scientists are perceived as less competent than their male peers. The high-profile MIT report (1999) showed that women faculty were increasingly marginalized as they progressed through their careers at that institution, subject to disparities in salary, lab space, awards, resources, and response to outside job offers, despite having equal professional accomplishments to their male colleagues.
- *Salary differences and low status* continue to plague women across sectors of employment.
  - In academic positions, although men far outnumber women in all types of institutions by a ratio of 2 to 1, this gap is most prevalent in research-oriented, doctorate-granting, and comprehensive institutions (Nelson 2004). Women are concentrated in medical schools and two-year institutions.
  - Male scientists and engineers are more likely to be employed full-time, and in the field of their highest degree, while women are more likely to work part-time or involuntarily outside their fields (NSF 2004b).
  - College-educated women in male-dominated fields earn 76% of what college-educated men earn one year after graduation (AAUW 2007).
  - Engineering and computer science graduates continue to earn the highest salaries (NSF 2005) at both the bachelor's and master's levels. Since women earn 21% of both BS and MS degrees in engineering and 25% and 31% of computer science BS and MS degrees, respectively, these salary disparities have lifelong implications for women's earnings (NSF 2007a).
- Issues of *work-life balance* are more significant for women.
  - Long times to doctoral degrees and a growing expectation for postgraduate education ("postdocs") delay opportunities to establish stable careers and families for scientists and engineers, as compared to those in other fields. Although the median age (31) for doctoral degree attainment in engineering, life and physical sciences is lower than in the social sciences (33), humanities (35) or education (44), multiple postdocs for STEM PhDs can contribute to postponement of families and careers (NSF 2006b).
  - Women in academic STEM positions lag behind their male counterparts on a number of measures of career success (NSF 2004a). If they are married with children, they fare even worse, hitting the "maternal wall" (Williams 2001). Academic women who postpone children until later in their careers are more likely to achieve tenure than those with early children (Mason & Goulden 2004; NSF 2004b).

WHAT IS BEING DONE?

- Educational approaches to generate interest and improve preparation for STEM careers

Programs targeting girls and women from preschool to graduate school seek to build confidence, offer role models, and provide support in chilly climates. Based on evidence that girls often perceive STEM as narrow, abstract, and lonely, many projects highlight uses of STEM to solve human problems. Addressing teacher and parent support is also crucial. Often these efforts also benefit boys and men (AAUW 2004; NSF 2007b). However, these efforts are not broadly coordinated, and their impact has been limited to date. Some interventions risk essentializing differences as unchangeable traits of the group (e.g., girls aren't good at math, girls like applied problems) rather than as responses to the systems in which girls have been taught (Boaler 2002).

- ADVANCE programs, http://research.cs.vt.edu/advance/index.htm

As a response to the MIT report (1999), the National Science Foundation has sponsored ADVANCE projects for "institutional transformation" to reduce gender disparities at the university level. These projects seek to increase women's representation on science faculties and campus administration, through data-gathering, policy review, support of women's research and leadership development, and attention to equity in hiring, retention, and climate.

- Endeavors for women in STEM by non-governmental organizations (NGOs)

Many NGOs provide career information, grants, networking, mentoring, and research on women in science, and support programs for girls and young women. Some are listed below.

RESOURCES AND FURTHER READING

Association for Women in Computing

Association for Women in Mathematics

Association for Women Geoscientists

Association for Women in Science

Graduate Women in Science

American Association of University Women

National Research Council Committee on Women in Science and Engineering

National Center for Women in Information Technology

American Chemical Society Women Chemists Committee

American Physical Society Committee on the Status of Women in Physics

MentorNet

Society of Women Engineers—see annual review of literature, www.swe.org/magazine

Women in Global Science and Technology

CITATIONS

AAUW, American Association of University Women. Washington DC: AAUW Educational Foundation. www.aauw.org

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