

Does Gender Bias Still Affect Women in Science?

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SUMMARY The percentage of women employed in professional scientific positions has been low but is increasing over time. The U.S. National Institutes of Health and the National Science Foundation have both implemented programs to improve women's participation in science, and many universities and companies have diversity and equity programs. While most faculty and scientists believe that they are fair and unbiased, numerous well-designed studies published in leading peer-reviewed journals show that gender bias in sciences and medicine is widespread and persistent today in both faculty and students. Recent studies show that gender bias affects student grading, professional hiring, mentoring, tenure, promotion, respect, grant proposal success, and pay. In addition, sexual harassment remains a significant barrier. Fortunately, several studies provide evidence that programs that raise conscious awareness of gender bias can improve equity in science, and there are a number of recommendations and strategies for improving the participation of women.

KEYWORDS STEM, bias, gender, medicine, science, women

INTRODUCTION

In 2015, women constituted half of the college-educated U.S. workforce in science and engineering but only 28% of workers in these occupations (1). Since 2005, women have received more Ph.D. degrees in life sciences (biological, biomedical, agricultural, nature resources, and health sciences) than men, but fewer women than men progress through the academic ranks, and only 31% of U.S. National Institutes of Health (NIH) grant recipients are women (2). Similarly, in the United Kingdom, women make up only 23% of the scientific workforce (3). Numerous well-designed studies published in leading peer-reviewed journals show that gender bias in science disciplines and medicine is persistent today, despite decades of programs designed to mitigate the problem. This review addresses the current evidence of gender bias, effects of gender bias on the careers of women in science, and steps to improve the inclusion of women in science.

HIRING, PROMOTION, GRANTS, AND TENURE

A number of studies have shown that professional evaluations are affected by gender. A randomized double-blind study published in 2012 in the *Proceedings of the National Academy of Sciences of the United States of America* included 127 faculty from

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research-intensive universities who were asked to evaluate resumes for a lab manager position. The resumes were identical except for the first names, which were varied by gender: John or Jennifer, names that were previously screened for equal likability and recognizability, without apparent ethnic associations. The authors found that both male and female science faculty rated the apparent “male” applicant as significantly more competent and hireable than the identical “female” applicant ($P < 0.001$) (4). Subjects also recommended more mentoring opportunities for the applicant identified as a male and recommended that “he” receive a salary almost \$3,500 more annually than for “her.” However, the identified female applicant was considered to be more likeable, showing that faculty project their gender expectations onto resumes. This 2012 study confirms the results of a study published in 1999 in which 238 academic psychologists (118 male and 120 female) evaluated a resume randomly assigned a male or female name (5). The subjects gave the “male” applicant better evaluations for teaching, research, and service and indicated that they would be more likely to hire the man than the woman. A 2013 study asked 243 graduate students to evaluate research paper abstracts where the researchers had systematically varied the gender of each abstract author (using a random sampling of the most popular names from the U.S. Social Security Administration’s database of people born in the 1960s, thus reflecting majority U.S. population demographics). Subjects rated papers with male-named authors as having higher scientific quality, again on identical abstracts (6). In 2014, M.B.A. students were assessed experimentally in a study by asking them to “hire” a candidate for a mathematics job when given information that included the candidates’ gender and math scores. Researchers stated that “both male and female subjects are twice more likely to hire a man than a woman” ($P < 0.003$) (7). Strikingly, the subjects hired the male even when his past math scores were lower than those of the female. These studies parallel results found in the general business environment, where managers prefer to hire males over equally qualified females (8). A 2018 study of over 2,000 job applications found that for college graduates with high grades, applicants with male names were almost twice as likely to be called by employers as applicants with female names with equal grades (9). Bias in hiring may additionally be fueled by bias in letters of recommendation evaluating the competencies of women. For example, a 2003 study found that letters for women were found to be shorter and to be missing essential evaluations of technical skills (10), and a 2015 article reported similar problems persisting (11). While these studies suggest that there may be gender bias, it is possible that the letters for women differed because the women performed less well. Gender bias can also affect professional evaluations, including for promotion. Researchers at Harvard University mathematically analyzed the effect of publication numbers on the ability of faculty to achieve tenure in the field of economics: the more papers published, the more likely a professor is to receive tenure. The researchers then analyzed with whom a faculty member published. They found that whether male faculty published with female coauthors or with authors of both genders, they received approximately the same amount of credit (6 to 8% credit in their model). If women published with other women authors, they received about 9% credit, but remarkably, if women published with men, the women received less than 1% on the credit scale (12). This indicates that if a woman publishes with a male coauthor(s), her contributions are undervalued. There is also evidence that bias affects peer review in grant funding, a key component in academic promotion and tenure and often in hiring. A 2018 study found that when comparing researchers who had equivalent past funding success rates, male applicants were favored over females. Significantly, this apparent gender bias disappeared when new procedures were instituted which included gender bias training (13). Only 31% of NIH grantees are women; however, their funding longevity after receiving their first major NIH grant is comparable to that of their male counterparts (2). The authors noted that the most striking difference was due to women’s initial underrepresentation in the pool of grant applicants, presumably at the assistant professor level. However, the paucity of women faculty in STEM (science, technology, engineering, and mathematics) in academia persists, with decreases in women faculty at increasing

ranks. The largest difference is seen at the full professor level, with only 23.5% of STEM full professors being women nationally.

STUDENTS AND BIAS

Bias affects students in a number of ways. One study showed that bias begins early during education and can have career-impacting effects. In math, the girls outscored the boys on an exam graded anonymously, but the boys outscored the girls when the teachers knew their names (14). Similarly, 6th-grade teachers gave lower scores to girls for math, even though the girls scored better than the boys on national standardized tests. The effect was not the same for tests on other subjects, such as English and other languages, where stereotypical expectations did not disadvantage girls (14). While it seems that grading a math exam would be free of subjective determinations, these data show that gender bias can affect evaluations that would *prima facie* seem to be objective. Gender bias also alters faculty responses to students applying for university positions. In 2015, a study of 6,500 randomly selected professors from 259 American universities responding to sham student emails, varied by gendered or ethnic names, showed that “Professors were more responsive to white male students than to female, black, Hispanic, Indian or Chinese students in almost every discipline and across all types of universities” (15). This responsiveness provides a significant advantage to those with typical white male names in the United States. Additionally, science students show gender bias against each other (16). When 1,700 biology undergraduates were asked to identify classmates who were “strong in their understanding of classroom material,” the authors reported that “the male students underestimated their female peers, overnominating other men over better-performing women.” Many studies show that both men and women are biased against women, but this study showed a gender bias 19 times higher in male than in female students. This bias against women’s intellectual ability apparently starts at an early age in children, as 6-year-old girls are less likely to think that women can be “really, really smart,” compared to boys thinking that men can be so, but by the age of 6 years, all children expected women to be nicer than men (17).

Students are also biased when rating female faculty. While most published studies cannot formally exclude the possibility that men are in fact better teachers than women, one ingenious study employed an online teaching course structure with one male and one female instructor. Half of the students with the female instructor were told that their instructor was male, and half of the male instructor’s students were told that their instructor was female. The female instructor’s overall score was slightly better than the male instructor’s ratings; however, the perceived male scored better than the perceived female (18). Differences in ratings due to gender were statistically significant in several aspects of rankings. For example, when both instructors returned test scores to the students at the same time, students believed that the male instructor had taken an acceptable amount of time to grade their tests but thought that the female instructor had taken too long. Significant differences in gender ratings were not found in several categories, including how helpful, consistent, or responsive the professor was or how s/he gave feedback. Student evaluations of teaching are an important component of the assessment of faculty performance, teaching awards, and often tenure, so this bias against women faculty may have a significant effect on the careers of women faculty. Finally, while many believe that gender bias is waning and younger people are spared, these studies suggest that bias is not confined to older scientists and faculty but is also apparent in young students today. Student bias was also shown by the research results discussed above, where students demonstrated gender bias when evaluating resumes and abstracts (6, 7).

RESPECT, ACCEPTANCE, SALARIES, AND INSTITUTIONAL CULTURE

Gender bias also shapes how respectfully faculty are treated. For example, women often comment that their professional titles are not used as frequently as men’s titles. This was documented in a study of 321 introductions at Internal Medicine Grand Rounds that revealed that if the introducer was female and the speaker was male, formal titles (i.e., Dr.) were used 95% of the time. However, if the introducer was male

and the speaker was female, a formal title was used only 49% of the time ($P < 0.001$) (19). Gender can also affect how much respect is given to a woman's professional recommendations. In 2017, researchers studied the computer science community and found that men's and women's pull requests (for computer code improvements) were similarly accepted; however, when programmers could easily be identified as women based on their names or profile pictures, the acceptance rate for their suggested code improvements dropped by 12% ($P < 0.001$) (20). The authors did not detect differences deriving from other parameters, including open source, whether the person was considered an insider, how much experience the coder had, the number of projects, the need for code change, or the size of recommended changes in code.

Gender also affects salaries. In a 2012 *JAMA* report, the authors state, "Male gender was associated with higher salary (+\$13,399; $P = 0.001$) even after adjustment in the final model for specialty, academic rank, leadership positions, publications, and research time" (21). A second study published in 2016 in *JAMA Internal Medicine* found that at 24 U.S. medical schools, "significant sex differences in salary exist even after accounting for age, experience, specialty, faculty rank, and measures of research productivity and clinical revenue." The study found a \$19,878 salary difference due to gender (95% confidence interval [CI]) (22). Other research has shown that women receive better job performance evaluations but fewer promotions (23) and that a woman being successful in a traditionally male field caused her to be disliked and receive negative consequences (24).

Bias also affects service work in academia in general. Women faculty carry more of the less-respected academic service responsibilities (sometimes referred to as the institutional housework), and, in turn, these tasks do not increase the status of women and may indeed compete with the time needed to advance research and publications required for tenure and promotions (25). While it is possible that in academia, the women are delegated these service duties because they are less productive or professional, a clever set of studies suggests that gender bias is at work. Research studies using monetary rewards on blinded, mixed-sex groups (where participants did not know the individuals in the group) showed that women and men both expect women to volunteer for tasks even when it reduced their reward but benefitted others in the group. In a further study, "managers" were assigned the task of procuring volunteers from the group by clicking on photos of subjects. The managers (both male and female) asked women to volunteer for the reduced reward 44% more often than they asked men (26). Indeed, women were 48% more likely than men to volunteer for a task that benefitted the group, even when it disadvantaged the women. The authors recommend that administrators in management/academia find ways to distribute tasks more equitably so that women's work for the institution does not harm them professionally.

The book *Gender Shrapnel in the Academic Workplace* (27) describes other cultural challenges that women face in traditionally male institutions: women professionals may not be discriminated against overtly but are instead exposed to frequent smaller insults that cumulatively cause damage. The author cites examples of women being interrupted in meetings, not being listened to, hearing others credited with their idea or work, being accused of plotting with other women, or being excluded from group decisions or informal events (e.g., golf outings or poker nights, etc.). She asserts that dealing with such microaggressions saps energy from women that could otherwise be devoted to professional productivity. Indeed, one study showed that women faculty in science and engineering who were planning to quit their jobs intended to do so because of their department's climate (28). The definition of climate included aspects such as perceptions of exclusion; the quality of relationships with colleagues, including the ability to ask for and receive professional assistance; the belief in the leadership of the department; and the likelihood of positive institutional change.

Professional success can further be impeded by sexual harassment, as detailed recently by the U.S. National Academy of Sciences (29). Numerous scandals and lawsuits at universities over the past several years have underscored continuing problems with sexual harassment in academia. A study published in 2016 on 1,719 NIH recipients of

career development grants in academic medicine reported that 30% of female doctors have been sexually harassed (30). Almost half reported that it negatively affected their careers. Indeed, it has been claimed that sexual harassment is a main reason why women leave science (31). There were so many reports of sexual harassment that the National Science Foundation (NSF) released a press statement in 2016 condemning harassment, encouraging reporting offenders, and threatening to block funding to institutions that do not address issues of sexual harassment adequately. In 2018, the American Association for the Advancement of Science (AAAS) instituted a policy to allow revocation of the status of elected AAAS Fellows and stated that misconduct and harassment in science and engineering will not be tolerated (32).

The many difficulties that women in science face are compounded by the differences in how men and women perceive equity and respect in the work environment, with men often being unaware of the concerns and challenges that women experience (27, 28, 33).

RECOMMENDATIONS: EDUCATION, DATA ANALYSIS, HIRING, START-UP, AND MENTORING

Together, these studies indicate that gender bias, inequity, and harassment are common today, despite university and federal programs to promote equity and diversity and to increase the participation of women in science. Thus, these issues must be taken into consideration in all aspects of the education and careers of women in science. Gender bias can have significant effects on grading, letters of recommendation, hiring, promotion, tenure decisions, mentoring, salary, acceptance rates for publication, procurement of grants, and respect. These in turn likely have major cumulative effects on the careers of women.

In recent years, many prominent faculty, universities, and research institutes have been in the news for having been accused of or sued for gender bias, pay inequity, and/or failure to deal with sexual harassment in science and medicine. The list includes the University of Rochester, the University of Chicago, the Salk Institute, Michigan State, the University of Wyoming, Columbus State University, the University of Arizona, Dartmouth College, Clemson University, Pittsburgh's Graduate School of Public Health, Children's Hospital of Philadelphia, the University of Denver, Ohio State, Lehigh University, and the University of Miami, to name a few. These reports underscore the need for institutions to address issues properly in order to protect scientists and avoid lawsuits, which are expensive, reputation damaging, and painful for all involved. In response to widespread complaints, U.S. national funding agencies have announced as early as January 2016 that they will discontinue funding to institutions that do not adequately address complaints (NSF 2016 [https://www.nsf.gov/news/news_summ.jsp?cntn_id=137466]), and the NIH launched an anti-sexual-harassment website (<https://www.nih.gov/anti-sexual-harassment>).

While most faculty and students will state that they are not biased against women, research shows that gender bias is widespread today in faculty and is continuing in students as well. The apparent contradiction between self-perceptions and reality is explained by the bias operating at the unrecognized, unconscious level; thus, it is also frequently called implicit bias or cognitive bias. This bias is not intentional but is rather absorbed through the general culture, where it permeates from societal norms of what roles men and women are expected to fill. Indeed, most studies show that both women and men are biased against women in science disciplines. Thus, raising conscious awareness of gender bias via seminars, manuscripts, or programs may in itself aid in addressing the problems. Individuals or groups (departments, lab teams, and leadership) can take Harvard University's implicit bias test at <https://implicit.harvard.edu/implicit/> to measure and understand their own biases. If faculty understand that bias truly continues to exist in well-educated populations today, they will better understand the need for vigilance and training programs. Gender and racial/ethnic/cultural bias training should be implemented specifically in all circumstances and committees that evaluate student and faculty performance, including hiring, mentoring, promotion,

tenure, awards, grant applications, invitations to speak at conferences, peer review of teaching or manuscripts, annual performance evaluations, and similar activities. Indeed, several recent studies indicate that effective training and education programs can increase motivation and competence to promote gender equity (34, 35) and increase fairness in hiring (36), equity in grant awards (13), and the promotion of women to leadership positions (35). In light of the studies showing gender bias in young students, education in undergraduate and graduate programs is warranted as well. One key area in which there is an absence of data is the effect of gender bias on institutional review boards, such as human subjects and animal care and use committees, where anecdotal evidence suggests that bias may be at work but for which no study has been reported. There needs to be continued funding to monitor progress over time, measure the effectiveness of specific interventions, and ensure adequate funding for studies of groups large enough to be a sufficient representation of the population.

Other measures to improve equity include gathering and analyzing data by department for comparison to national averages for faculty gender composition, as reported in the AAMC data for basic science and clinical departments in medical schools and the National Faculty Distribution Survey prepared every 2 years by Oklahoma State University's Office of Institutional Research and Information Management and the Vice President of Administration and Finance, which covers approximately 80 U.S. institutions and almost 100,000 faculty and 300 disciplines organized by the Carnegie classification (37). If a department is significantly below the national average in its number of women faculty at rank, some additional attention may be needed in the department, e.g., attention to recruitment and search committee actions and/or assessing the department's climate, because the latter has been shown to be crucial for the recruitment and retention of women in science (28). It is also important to assess tenured and tenure-track faculty positions, because tenure status typically gives greater job security, status, pay, and participation in institutional governance. This is a key point because women are more often working in nontenured positions (38): men currently hold 62.4% of tenured university positions, and women hold 37.6%. In addition, success rates for women and men should be analyzed in applications, hiring, tenure, promotion, and award rates, etc.

Other recommendations to improve gender equity in science include the use of matrices to count/score job or promotion candidates in an unbiased manner, the inclusion of diverse and female committee members for faculty searches and on promotion/tenure committees, the inclusion of a designated diversity representative on search committees to raise awareness and aid in recruiting female and/or minority faculty, and ensuring that faculty write letters of recommendation fairly for women and men by addressing specific skills in all letters and writing similar-length letters for women and men (10, 39–41). Attention should also be paid to the wording in advertisements for science positions to encourage recruiting female and minority candidates by stating the university's commitment to inclusion and diversity. Research shows that some words associated with male stereotypes may also discourage female applicants (42). During the search process, care should be given not to apply job search criteria strictly to female and minority candidates and loosely apply criteria (or be "forgiving") to male candidates, assuming that the men will pick up the skills required. For example, a recent study indicates that search committee members may accidentally bias decisions against women by considering relationship status and perceived likelihood of a partner relocating geographically for female but not for male job applicants (43). During hiring negotiations, start-up packages should be funded equitably. One study published in 2015 on 219 faculty (127 men and 92 women) showed that men received on average \$539,000 more than women in start-up funds ($P < 0.001$), even though "[t]here were no differences between men and women in terminal degree or years since receiving terminal degree" (44). Smith et al. developed a highly successful recruitment program that included a kit with template letters and in-person oral bias training by a faculty member for the search committee and an independent faculty member contact to provide information and support for the applicant. The intervention

resulted in STEM search committees that were 6.3 times more likely to make an offer to a woman candidate than the control group that had followed the standard human resource procedures (41). The women who were offered a faculty position were also 5.8 times more likely to accept an offer (41).

Finally, we must make sure to mentor “outsiders” (women or other minorities), as women in male-majority workplaces often report being excluded or feeling isolated (33). Some faculty do not want to meet alone or go to dinner with a faculty member or student of the opposite sex for fear of sexual harassment, false accusations, or the appearance of impropriety. This can create problems for mentoring women in male-dominated fields, even though mentoring is critical (45), and department relationships are a key component of the climate that may cause women to leave STEM fields (28). Conscious awareness and sensitivity are key in dealing with this difficult issue.

Despite the documented difficulties, women are increasingly successful in science. Numerous factors likely work together to produce this success, including increasing awareness of the competence of women in science, the existence of more women role models, institutional gender bias training, the conscious awareness of the need for professional fairness between men and women, and the implementation of programs to increase the inclusion of women at all levels. Certainly, faculty, department chairs, search committee chairs, upper-level administrators, and personnel working in equity and diversity deserve much credit for the progress that has been made.

RESOURCES

A number of government agencies, universities, and scientific societies have resources available online that can be used to address various gender and bias issues. The University of Colorado at Boulder and Montana State University have large toolkits available online (www.strategictoolkit.org and <http://www.montana.edu/nsfadvance/formsresources/index.html>) that cover practical actions relating to many of these topics for “universities [to] create institutional environments that support the success of women scholars in STEM” (44, 46).

In addition, many resources are available, such as Harvard University Project Implicit (<https://implicit.harvard.edu/implicit/>); the National Science Foundation ADVANCE: Organizational Change for Gender Equity in STEM (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383); the NIH Office of Equity, Diversity, and Inclusion (<https://www.edi.nih.gov/people>); the NIH Scientific Chief Officer for Workforce Diversity, Hannah Valantine (<https://diversity.nih.gov/>); the American Association for the Advancement of Science SEA Change (<https://seachange.aaas.org/>); the National Science Foundation ADVANCE Resource Coordination (ARC) Network (<http://www.equityinstem.org/community/>); and the Society for Neuroscience (<https://neuronline.sfn.org/Collections/Increasing-Women-in-Neuroscience-Toolkits>).

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