

Science & Society

Overcoming gender bias
in STEM

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Despite prevalent diversity and inclusion programs in STEM, gender biases and stereotypes persist across educational and professional settings. Recognizing this enduring bias is crucial for achieving transformative change on gender equity and can help orient policy toward more effective strategies to address on-going disparities.

International Women's Day, now a prominent fixture in numerous organizational agendas, has been celebrated once again this year, so too has Women's History Month, which is observed in multiple countries (including the USA and UK) in March and highlights the contributions and achievements of women throughout history. These annual observances are encouraging because they underscore a heightened focus on gender bias across societies. Growing awareness of gender inequity is also a feature of contemporary academia, where diversity programs and gender equity plans are becoming essential elements in the governance of higher education and research.

However, as we move beyond another series of celebrations of female achievement, the question arises, what tangible advancements have been made in the pursuit of gender equity?

Systematic, high-quality research suggests that despite visible gains, gender biases and inequities remain deeply entrenched.

Indeed, a 2024 World Bank report shows that the global gender gap for women in the workplace is far wider than previously thought, and despite decades of effort, not a single country in the world provides equal opportunity for women relative to men [1]. Meanwhile, a major 2023 United Nations report showed that nine out of ten individuals of all genders remain biased against women [2], a figure that is unchanged from the previous report a decade earlier.

These trends can be seen in academia, including in STEM (broadly defined here to include disciplines in the life sciences, physical sciences, engineering, mathematics, computer science, medicine, and health sciences), where they have wide-ranging effects. While more and more women have entered higher education and research, female attrition rates remain persistently high [3]. For example, after establishing an academic career in STEM, women are two times more likely than men to abandon that career [4], often due to their experiences at toxic workplaces [3]. Furthermore, in academia, just as in 'Fortune 500' companies, women are still under-represented in higher-level positions, and they experience greater precarity in those positions, with a higher likelihood of being poorly evaluated, unfairly criticized, retaliated against, pushed out, demoted, and/or fired, particularly if they complain or challenge the status quo [3,4]. In addition, these trends are accentuated for women of color and gender- and sexuality-minority students and staff [3,5].

The persistence of biases is highlighted in STEM fields such as immunology and other subspecialties within medicine that are female dominated yet retain major biases against women [6,7]. For example, more than 70% of American Academy of Allergy, Asthma, and Immunology (AAAAI) fellows in training were reported to be female in 2017 [6], yet a recent survey by

the AAAAI indicates that 63% of academic leadership roles in the field are held by men [7]. Women also remain under-represented in editorial boards and in the senior leadership of key immunology-focused journals [6]. Only 17% of articles such as editorials that are associated with leadership in the field of allergy and immunology are written by women [6]. In immunology and across science as a whole, women receive fewer awards than men, and these awards are associated with less monetary value, public attention, and career advancement than those of male researchers [3,7]. Furthermore, women are generally paid less than men; for example, it is estimated that female physicians in the USA will earn US\$2 million less than their male colleagues over a 40-year career [7]. In various disciplines and professions, including primary healthcare, the earnings gap between men and women has increased in recent years.

Such trends, many of which are common across STEM and academia, likely reflect the entrenched nature of gender stereotypes. For instance, a long-term study of college students showed remarkable stability of gender stereotypes over a period of 30 years [8]. Despite their substantially increased participation in the workplace over this timeframe, women were still seen, for example, as more warm but less competent and independent than men [8]. A corresponding pattern is seen in other workplace sectors that were once dominated by men but that now exhibit an equal representation of women. Gender stereotypes remain firmly embedded in veterinary medicine, for example, despite equal numbers of women in this profession today [9].

The enduring nature of gender bias is evident from 'deep-time' health data, looking at human health across many millennia. For example, recent bioarchaeological research indicates that the significant stature differences between men and women in

northern Europe during the Neolithic period cannot be explained by genetic or dietary factors. Instead, researchers suggest that the stature differences stem from gender inequality. They point to the fact that the closest parallels for the kind of extreme height dimorphism seen in the Neolithic period are also observed today in countries that are known for their cultural preferences and biases toward male children [10]. The extraordinary persistence of such biases is highlighted by another study that examined 10 000 individual tooth records from European archaeological sites dating back to circa 1200 AD [11]. Disparities in tooth health between women and men were used as a measure of gender inequality in different locales. The study documented that this historical measure of gender bias significantly predicted contemporary gender attitudes at the same locales, despite monumental socioeconomic and political changes over the intervening millennium [11].

Such studies are relevant because they help us to better understand why significant gender biases have persisted over time, even as women have become better represented in STEM [4,9]. They highlight the incredible power and fidelity with which gender norms are culturally transmitted across generations and the substantial work that will be needed to level the playing field for women across all sectors of society. While much of the messaging we receive tells us that things are getting better, it remains at odds with the experience many women have in higher education and research as they progress in their careers [3]. An awareness of the resilience of gender bias helps us understand and appreciate these experiences.

Achieving true equality requires recognizing the deep-rooted nature of gender bias. Despite the growth of diversity and equity initiatives, many overlook the profound challenges that engrained biases and inequalities present, drawing into

question their potential for real impact. For instance, unconscious bias training, as shown in several studies, tends to be ineffective or even counterproductive, with the potential benefits often being temporary. People are frequently resistant to the imposition of such training, overestimate its effectiveness, or come to believe that bias, being unconscious, is impossible to address [12].

Gender equity plans are equally problematic. They can easily become little more than a box-ticking exercise [13]. While such plans may be required to meet government recommendations, in practice, there is often little effective follow-through, inadequate investment of resources, and a preoccupation with figures and audit sheets instead of a genuine commitment to change [14]. In addition, an analysis of the effectiveness of gender equity plans in Europe, for example, suggests that gender equality work continues to be viewed predominantly as ‘women’s work’ [13]. The engagement of limited numbers of men in gender equity plan design and implementation is an important barrier to institutional transformation in higher education and research [13].

Even legal tools for dealing with gender inequities can be problematic. In the USA, for example, legal measures such as Title IX have not led to a significant decrease in incidents of sexual and gender harassment in academia. Sexual harassment law and policy development has focused narrowly on the sexualized and coercive forms of sexual harassment, not on the gender harassment type that research has identified as more prevalent and at times equally harmful [15]. Furthermore, judicial interpretation of Title IX has incentivized organizations to create policies, procedures, and training on sexual harassment; these focus on symbolic compliance with current law and avoiding liability but not on preventing gender discrimination and harassment[†].

These issues point to an additional serious limitation: the absence of accountability on gender equity [16]. Despite instituting gender equity plans and policies, leaders and line managers in most if not all academic organizations are not held accountable for diversity targets, and there are no repercussions for a lack of diversity, a lack of progress on meeting equity targets, or, indeed, for ongoing problems of sexual and gender harassment. Consequently, there is little incentive to create real change in higher education and research. This is particularly the case when equity measures undermine the very privilege from which leaders and line managers (who are overwhelmingly white, male, heterosexual, and able bodied) have often benefited [5].

Accordingly, it is clear that more needs to be done to address the persistence of bias in STEM specifically but in society more broadly. Organizations must alter their metrics but also change their culture [17]. They must focus not only on diversity but also on inclusion. This means measuring how many women they hire, how many they retain, how these women experience the workplace, how their careers advance, and how organizations deal with any problems that might arise, including accusations by such women of discrimination or harassment [3]. Robust accountability frameworks must be incorporated to ensure that organizations take action to address inequities identified through such assessments. Independent reviews of equity processes and their effectiveness must be conducted, and organizational leaders must be held accountable [16,17]. Moreover, by linking funding to performance on gender equity, a key lever for encouraging real change could be created [3,17].

Otherwise, the continued lack of robust accountability and enforcement mechanisms risks perpetuating gender equity plans, initiatives, and laws that are primarily

performative and that support complacency. Such initiatives may also reinforce the inaccurate perception that things are changing when they are not. Issues of diversity and equality must be embedded within the cultural organization of STEM institutions and include institutional frameworks, structures, and strategic plans; only then can real outcomes and behavioral changes ensue [14,17].

Achieving authentic gender equity in science and beyond also requires concerted efforts and functional collaboration among all stakeholders. This means that researchers, educators, journal editors, funding agencies, policymakers, and gatekeepers must all work together to address current inequities. It also calls for personal and individual responsibility. Everyone, irrespective of their seniority or direct experience with gender imbalance, has a role to play in challenging and changing the status quo by actively opposing neutrality on these critical issues.

Without concerted, interdependent actions from stakeholders to address deep-seated biases in science and more broadly across society, we are unfortunately likely to witness more International Women's Days and Women's History Months and indeed whole decades pass by with gender inequities and stereotypes remaining as intact as ever. Thus, this is a call for action to recognize the persistence of gender biases in STEM. While doing so may be disconcerting and even discouraging, facing current

realities head on is a critical step on the pathway to transformative change. Only by recognizing the deep-seated nature of the challenges surrounding gender discrimination can we develop the right tools to more effectively alter and reshape the underlying norms, structures, and practices that hold women back in higher education, research, and society.

Declaration of interests

M.M. is cofounder and director of the Academic Parity Movement (paritymovement.org), a nonprofit organization dedicated to addressing academic discrimination, violence, and bullying. The authors declare no other competing interests.

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