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Boosting the Sustainable Representation of Women in STEM With Evidence-Based Policy Initiatives

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Abstract

Women are missing from Science, Technology, Education, and Mathematics (STEM) fields, undermining intellectual inclusivity, meritocracy goals, national competitiveness, and high-quality advances. Solutions require not only hiring more women, but boosting their *sustainable representation* (i.e., their lasting, substantial presence and valued engagement). Evidence-based policies can shift organizational culture, enabling women's full and durable participation. The present review presents (1) numerous causes of women's underrepresentation in STEM and (2) evidence-based interventions to tackling these causes. Specific policy initiatives (derived from the scientific evidence) would promote the sustainable representation of women in STEM.

Keywords

STEM, gender, underrepresentation, interventions, sustainable representation

Tweet

To boost women's *sustainable representation* (their lasting, substantial presence and valued engagement) in STEM fields, we need evidence-based policy to shift organizational culture.

Key Points

- STEM organizations must focus not only on hiring talented women but also on creating professional environments that retain and support them.
- Boosting women's *sustainable representation* means supporting their lasting, substantial presence and valued engagement in STEM fields—through evidence-based policy.
- Causes of women's underrepresentation in STEM include gender-science stereotypes, gender bias, social identity threat, viewing STEM as incompatible with communal goals, and work/life balance pressures.
- Policies should (1) guard against bias in hiring, promotion, and gatekeeping professional opportunities; (2) reduce social identity threat; (3) recalibrate incentives to encourage instructors to restructure STEM education; (4) implement gender-inclusive policies; and (5) implement mentoring programs and reward female role-models.

Introduction

Promising initial trends in workforce diversification often fail to generate lasting organizational change (Dovidio et al., 2016; Green & Kalev, 2008). Indeed, recruiting women may be easier than successfully retaining them (C. C. Miller, 2012). Thus, STEM organizations must focus not only on hiring talented women but also on creating professional environments that enable women to comfortably remain and function at the highest levels. Evidence-based policies promote the *sustainable representation* of women—their lasting, substantial presence and valued engagement (Darhour & Dahlerup, 2013). Sustainable representation goes beyond mere numbers of female employees, focusing instead on outcomes that shape women's experiences: improving attitudes toward women in STEM, increasing the ability to recognize and contend with bias (Carnes et al., 2015), heightening women's sense of belonging, and reducing gender-biased,

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hostile work environments. Sustainable representation addresses problematic components of organizational cultures, rather than merely diversifying hiring.

Understanding obstacles that impede women's full participation enables evidence-based interventions. Besides reviewing known causes of women's underrepresentation in STEM, as well as interventions targeting these obstacles, successful policies must not inadvertently undermine women's ability to thrive. For example, mentoring helps female students, but burdens female academics. Thus, organizations can restructure incentives, to ensure that addressing gender equity does not fall disproportionately on women.

The Lack of Women's Sustainable Representation in STEM

Despite constituting half the population, women remain numerically underrepresented across the vast majority of STEM fields (Cheryan et al., 2017). When women do enter STEM, they often report experiences of gender bias (Robnett, 2016), sexual harassment, and even assault (Clancy et al., 2014). This in turn undermines STEM professionals' work (as illustrated in Perez, 2019), contradicts meritocratic values (Cech & Blair-Loy, 2010; Ellemers & Barreto, 2009), and undermines national competitiveness (e.g., Beilock & Maloney, 2015; Dasgupta & Stout, 2014; President's Council of Advisors on Science and Technology, 2012).

Underlying Causes

Several key causes help explain the lack of women's sustainable representation (Avolio et al., 2020; Dasgupta & Stout, 2014). First, widespread *stereotypes* typically portray STEM as male gender-typed, both explicitly (i.e., self-reported) and implicitly (i.e., automatic; e.g., Miller et al., 2015; Nosek et al., 2009). Because gender stereotypes are not only descriptive but also prescriptive (Rudman et al., 2012), they can undermine women's enthusiasm for participating in fields that are stereotypically masculine. For example, women often report not belonging in STEM (Cheryan et al., 2009), reducing STEM engagement (Moss-Racusin, Sanzari, et al., 2018). Second, people display *gender bias* against women in STEM fields (e.g., Moss-Racusin et al., 2012). When exposed to the reality of gender bias, women were less interested in STEM than men are; when instead told to expect gender equality, women's STEM engagement equalled men's (Moss-Racusin et al., 2018b). Furthermore, encountering gender bias correlated with women's lower STEM self-concept (Robnett, 2016).

A third cause is *social identity threat*, or women's (justifiable) concerns about their group's devaluation in STEM (Cheryan et al., 2009; Murphy et al., 2018; Steele et al., 2002). Masculine STEM cultures reduce women's sense of belonging and desire to participate in STEM (Cheryan et al., 2009), weaken their self-efficacy (Murphy & Taylor, 2012), and hinder their performance (Walton et al., 2015). Relatedly, stereotype threat (concern that one may confirm negative stereotypes; Steele et al., 2002) undermines women's academic STEM performance (Schmader & Beilock, 2012). Fourth is the perceived incompatibility between *communal (other-oriented) goals* (more typically endorsed by women) and STEM work, which affords agentic (self-oriented) goals (more commonly endorsed by men; Diekman & Benson-Greenwald, 2018).

Fifth, *work/life balance* disproportionately impacts women. Whether freely selected or biologically and socially constrained, lifestyle choices—such as caring for children or elderly family—can interrupt STEM participation (Ceci & Williams, 2011), more so for women than men (Cech & Blair-Loy, 2019). Rarity of paid parental leave and stigma associated with utilizing flexible work arrangements (Cech & Blair-Loy, 2014) compound the problem. Sixth, few women can serve as *mentors and role models* to subsequent cohorts (Dasgupta, 2011; Shin et al., 2016). In-group role models improve STEM self-concept, attitudes, and aspirations (Stout et al., 2011). Thus, lacking in-group role models has cascading influence on future cohorts (Rask & Bailey, 2002).

Scientific Evidence of Effective Interventions

Interventions targeting at least one known cause can improve sustainable representation of women in STEM. In-person trainings to reduce gender biases, led by trained facilitators, can boost bias literacy, break ingrained habits of stereotyping, and provide strategies for navigating gender issues (Carnes et al., 2015; Devine et al., 2017; Girod et al., 2016; Jackson et al., 2014; Moss-Racusin et al., 2016; Sekaquaptewa et al., 2019; Smith et al., 2015). Experiential interventions (Cundiff et al., 2014; Shea et al., 2019; Zawadzki et al., 2014) and high-quality videos can increase bias literacy (Pietri et al., 2017), reduce gender bias, improve attitudes toward women in STEM, engage anger and empathy (Moss-Racusin et al., 2018a), and increase the ability to identify gender bias (Pietri et al., 2017).

Interventions effectively targeting social identity threat (e.g., Cheryan et al., 2009, 2011; Miyake et al., 2010; Walton et al., 2015) can reinforce a valued part of women's identity (Cohen & Sherman, 2014), dramatically improving women's STEM test performance in both the laboratory (Martens et al., 2006) and STEM classrooms (Miyake et al., 2010). Modifying STEM environments can affirm feminine traits and values (Cheryan et al., 2009; Good et al., 2010). Highlighting STEM's communal aspects reduces perceived goal incongruity (e.g., Brown et al., 2015; Diekman et al., 2011). Learning that scientists work with and help others encourages attraction to STEM (Diekman et al., 2011; Fuesting et al., 2017).

Restructuring STEM education can tackle both perceived goal incongruity and social identity threat (e.g., Belanger et al., 2017; Bennett & Sekaquaptewa, 2014; Dasgupta et al., 2015; Jones et al., 2010; Latulipe et al., 2018). Examples include service learning, social connection (Carr & Walton, 2014), and active learning (Belanger et al., 2017; Freeman et al., 2014; Handelsman et al., 2007). These particularly benefit female students (Gross et al., 2015; Latulipe et al., 2018), especially when women are in the majority (Dasgupta et al., 2015) or when men in the group have addressed gender biases and promoted egalitarian norms (Bennett & Sekaquaptewa, 2014; Lewis et al., 2019).

Institutional support can ease women's burden to manage competing professional and personal demands and promote their sustainable representation in STEM. For example, gender-inclusive policies (holding supervisors accountable, paid parental leave) encouraged female engineers and reduced social identity threat (Hall et al., 2018). Similarly, support programs (hiring a designated grant coordinator, offering grant-writing boot camps, funding a faculty Family Advocate, and training Equity Advocates) increased women's grant funding (Smith et al., 2017) and job satisfaction (Smith et al., 2018). Furthermore, paid paternity leave increased women's STEM engagement, belonging, and aspirations (O'Brien & Moss-Racusin, 2020). Paid parental leave improved attitudes toward women's workplace equality in nine countries (Omidakhsh et al., 2020).

Finally, interventions can present relatable female role models and mentors (e.g., Pietri et al., 2019; Stout et al., 2011), encouraging women to view STEM as less masculine (Young et al., 2013), with heightened belonging, self-efficacy, and valuing of STEM (Dasgupta, 2011; Lockwood & Kunda, 1997; Morgenroth et al., 2015). Even brief exposure enhances female students' identification with and interest in STEM (O'Brien et al., 2017; Ramsey et al., 2013; Stout et al., 2011), when role models convey communal goals (Diekman et al., 2011; Fuesting & Diekman, 2017), do not fit masculine STEM stereotypes (Cheryan et al., 2011), and worked hard for their success (Asgari et al., 2012; Bagès et al., 2016). In addition, among women with multiple marginalized identities, a scientist with an overlapping racial/ethnic identity is more effective at promoting belonging than a scientist only matching their gender identity (Pietri et al., 2018, 2019).

Beyond role models, women must access involved mentors (established STEM professionals who offer regular interactions, guidance, and support; Gibson, 2004). Mentoring increases retention of female STEM majors (Dennehy & Dasgupta, 2017) and is one of the best predictors of women's reported STEM involvement (Hernandez, Bloodhart, et al., 2017); lacking mentors is one reason why women leave engineering majors (Marra et al., 2009). Mentors are most helpful when students feel similar to mentors (Hernandez, Estrada, et al., 2017), when mentors share mentees' social identity (Dennehy & Dasgupta, 2017), and emphasize that they trust the mentee to improve and thrive (Yeager et al., 2014).

Evidence-Based Policy to Boost Women's Sustainable Representation in STEM

Change Cultures, Not Individual Women

Women should not bear the onus for changing to better fit existing STEM cultures. Rather, policy initiatives should reshape STEM workplaces to promote excellence, inclusivity, and sustainable representation for all. For example, focusing mentor programs only on women implies that the female mentees need to be "fixed" (Thomas et al., 2015) and overburdens female mentors (Guarino & Borden, 2017). Thus, particularly efficacious programs focus on developing a specific skill (e.g., grant-writing) and are open to all (Smith et al., 2017, 2018). Similarly, addressing perceived goal incongruities should not simply focus on making women less communal, but rather, changing the perception that STEM work is incompatible with communal goal pursuit.

Recommendation 1: Guard Against Bias in Hiring, Promotion, and Gatekeeping of Other Professional Opportunities

Institutions should seek to establish mechanisms to prevent the application of widespread gender stereotypes and biases at key professional decision points, through evidence-based workshops and trainings or more immersive experiences. Key decision-makers (such as hiring committees, promotion and tenure committees, chairs and program directors, and boards of trustees) should be particularly encouraged to participate. Furthermore, women are often underrepresented relative to men as speakers for invited colloquia at prestigious universities (Nittrouer et al., 2018) and conferences (Farr et al., 2017; Mehta et al., 2018). Visible female role models can stimulate women's interest in STEM, so institutions should strive for speaker gender balance.

STEM workplaces should promote equity in hiring processes, including training faculty as Diversity/Equity Advocates who guard against subtle biases and crafting job advertisements that do not systematically alienate applicants from underrepresented groups. For example, language associated with masculine stereotypes (e.g., *dominant, competitive*) systematically deters female applicants (Gaucher et al., 2011), and gender-exclusive language (e.g., utilizing *he* to refer to *she* or *he*) undermines women's sense of belonging, motivation, and predicted job identification (Stout &

Dasgupta, 2011). Relatedly, female (vs. equally-qualified male) candidates' recommendation letters tend to be shorter (Trix & Psenka, 2003), employ fewer "standout" adjectives (e.g., "outstanding"; Schmader et al., 2007), and utilize more communal words (Madera et al., 2009) and doubt raisers (Madera et al., 2019), all of which undermine hiring. Finally, explicit evaluation rubrics allow members (blind to applicant demographic characteristics) to rate applicants on demonstrated ability to meet the criteria in the job advertisement. Completing these ratings independently (and circulating average scores) before search committee meetings can lessen evaluators' tendency to subtly shift evaluation criteria to benefit majority group candidates (Phelan et al., 2008; Uhlmann & Cohen, 2005).

Recommendation 2: Utilize Tested Means to Reduce Social Identity Threat

Adopting gender-inclusive institutional policies will help alleviate social identity threat among female scientists (see Hall et al., 2018). Moreover, incentivizing STEM instructors to implement brief validated values affirmations can improve female students' grades (Miyake et al., 2010). Moreover, the physical classroom should not exacerbate social identity threat (Cheryan et al., 2009, 2017 e.g., displaying pictures of only White male alumni; Fitzsousa et al., 2019). Also, instructors can emphasize the communal aspects of STEM research and how it helps society (Fuesting et al., 2017).

Recommendation 3: Incentivize Educators to Restructure STEM Education Via Tested Strategies

Many of the best strategies require significant instructor effort (e.g., incorporating service and active learning). Thus, incentives should reward instructors for creating more inclusive classroom environments, through ongoing training on inclusive teaching and active learning. Indeed, STEM education researchers have validated workshops that teach instructors about these classroom techniques (Pfund et al., 2009; see also Moss-Racusin et al., 2016).

Furthermore, promotion and tenure processes rely on student evaluations, which tend to be biased against women (Mitchell & Martin, 2018). For female instructors, evaluations tend to reflect instructor likability (rather than effective pedagogy; Sprague & Massoni, 2005) and are often unrelated to student mastery of course material (Spooren et al., 2013). New policies should require instructors to document the empirically validated practices they adopt to promote classroom inclusivity. For example, instructors could report (and be rewarded for) their use of interventions to address social identity threat (Miyake et al., 2010), active learning exercises (Gross et al., 2015), or classroom policies that promote egalitarian norms among students (Lewis et al., 2019).

Recommendation 4: Implement (and Publicize) Institutional Gender-Inclusive Policies

Adoption of tested gender-inclusive policies should be opt-out (rather than opt-in) and available to all community members, to normalize utilization and guard against stigma (Cech & Blair-Loy, 2014). Paid parental leave should be based on employees' caregiver status (not gender or birthing status). Furthermore, accessible, affordable child care options minimize caregiving duties that disproportionately impact women's productivity in STEM. In addition, institutions can use regular, transparent salary audits and adjustments to eliminate gender wage gaps in STEM (e.g., Michelmore & Sassler, 2016). Finally, support for dual career couples includes publicizing formal spousal hiring procedures and providing designated career services staff for non-academic partners searching for local employment.

Recommendation 5: Implement Broadly Accessible Mentoring Programs for Women That Reward (Rather Than Burden) Female Mentors and Role-Models

Institutions should provide access to inspirational female STEM role models, including hosting events featuring prominent female scientists (Pietri et al., 2019; Stout et al., 2011). However, less prestigious events can create heavy service expectations for female scientists (Guarino & Borden, 2017), which may not benefit promotion and career success (Yoder, 2018). Women's role modeling labor should be rewarded, both financially and in formal evaluations.

New and creative techniques can make role models broadly accessible without additional burdens on female scientists; even brief exposure can spark female students' interest in STEM (Stout et al., 2011), so pictures and information about female scientists can be incorporated into STEM classroom spaces and lectures (Fitzsousa et al., 2019; Good et al., 2010). In addition, high-quality videos featuring successful female STEM role models could be shown to students during class lectures, at larger events, or online. Indeed, videos highlighting scientist role models spark female students' interest in STEM careers (Geena Davis Institute on Gender in Media, 2018; Pietri et al., 2020). Videos highlighting female scientists with multiple marginalized identities (e.g., a Black female scientist) may be particularly beneficial, because these women are highly underrepresented and thus often overburdened with service tasks (Turner et al., 2011). Of importance, female scientists with multiple marginalized identities also may be the most beneficial role models for female students with matching identities (Pietri et al., 2018).

Although women benefit from female mentors (Dennehy & Dasgupta, 2017), supportive male mentors can also promote women's careers in STEM (Blake-Beard et al., 2011). Thus, both female and male faculty should undergo validated trainings (e.g., Pfund et al., 2015) that improve their mentorship broadly, and particularly for students with marginalized identities in STEM. Moreover, incentive structures should ensure quality mentoring is a component of promotion and tenure.

Conclusion

Merely hiring more women will not reliably close longstanding STEM gender gaps. Rather, effective policies must promote sustainable representation, such that women are not only hired at rates proportionate to their representation in the broader population but also welcomed into environments that allow them to thrive. Numerous factors contribute to women's current lack of sustainable representation in STEM, but interventions can successfully target these causes. Furthermore, five specific policy recommendations derive from the scientific literature. Widespread implementation could boost women's sustainable representation in STEM, and in turn improve the climate of STEM workplaces and the innovations they generate.

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