Policy Insights from the Behavioral and Brain Sciences
2014, Vol. 1(1) 21–29

DOI: 10.1177/2372732214549471
bbs.sagepub.com
SAGE

Girls and Women in Science, Technology, Engineering, and Mathematics: STEMing the Tide and Broadening Participation in STEM Careers

Nilanjana Dasgupta[1] and Jane G. Stout[2]

Abstract

Scientific advances fuel American economic competitiveness, quality of life, and national security. Much of the future job growth is projected in science, technology, engineering, and mathematics (STEM). However, the supply of domestic students who pursue STEM careers remains small relative to the demand. On the supply side, girls and women represent untapped human capital that, if leveraged, could enhance the STEM workforce, given that they comprise 50% of the American population and more than 50% of the college-bound population. Yet the scarcity of women in STEM careers remains stark. What drives these gender disparities in STEM? And what are the solutions? Research points to different answers depending on the stage of human development. Distinct obstacles occur during three developmental periods: (a) childhood and adolescence, (b) emerging adulthood, and (c) young-to-middle adulthood. This article describes how specific learning environments, peer relations, and family characteristics become obstacles to STEM interest, achievement, and persistence in each period. Evidence-based policies and programs promise to eliminate these obstacles, increasing girls and women's participation in STEM.

Keywords

STEM, diversity, gender, achievement, stereotype

Tweet

As children, adolescents, and adults, girls and women face barriers in STEM fields for reasons related to school, peers, and family, but science offers solutions.

Key Points

- In childhood and adolescence, masculine stereotypes about STEM, parents' expectations of daughters, peer norms, and lack of fit with personal goals make girls move away from STEM fields.
- In emerging adulthood, feeling like a misfit in STEM classes, being vastly outnumbered by male peers, and lacking female role models make women avoid STEM majors or leave prematurely.
- In early to mid-adulthood, subtle gender bias in hiring and promotion, biased evaluation of scientific work, non-inclusive department climate, juggling work–family responsibilities, and difficulty returning after a family-related pause undermine the retention of women in STEM.
- Evidence-based programs and policies can remove obstacles for girls and women in STEM.

Introduction

In today's globalized world, scientific innovation is vital for American economic competitiveness, quality of life, and national security. Much of the future job growth in the United States will be in science, technology, engineering, and mathematics (STEM) and American businesses search globally for talent (National Academies, 2010). This raises concerns about Americans' preparedness for STEM jobs, given the small numbers of domestic students who enter these fields and the high attrition rate (often called the "leaky pipeline"). Women's untapped human capital could enhance the STEM workforce, given that they are 50% of the American population and more than 50% of its college-bound population (National Center for Education Statistics, 2013).

The leaky pipeline starts early. From middle school through college, female students perform worse on some

[1]University of Massachusetts, Amherst, MA, USA
[2]Computing Research Association, Washington, DC, USA

Corresponding Author:
Nilanjana Dasgupta, University of Massachusetts Amherst, Tobin Hall, 135 Hicks Way, Amherst, MA 01003, USA.
Email: dasgupta@psych.umass.edu

types of science and mathematics tests compared with male peers and report less confidence and aspiration (Else-Quest, Hyde, & Linn, 2010). Gender gaps in science and math *performance* have been closing, but gaps in STEM *self-concept and aspirations* remain large. Even when girls and women perform as well as their male peers on STEM tests or better, many lose interest and do not pursue advanced courses, majors, and careers in STEM, representing an exodus of talent among girls and women who could otherwise become the next generation of scientists, engineers, and creators of technology (for a review, see Dasgupta, 2011).

What drives gender disparities in STEM? Research points to multiple answers at different developmental stages. The reasons for gender disparities in childhood and adolescence differ from those in emerging adulthood or early-to-middle adulthood. Interventions aimed at closing the gender gap need to target multiple time points in the developmental trajectory. This article focuses on three developmental periods and identifies obstacles in each: (a) childhood and adolescence, (b) emerging adulthood, and (c) young-to-middle adulthood. Each section below describes learning environments, peer relations, and family characteristics that become obstacles creating gender differences in STEM interest, achievement, and persistence. Evidence-based policies and programs, if implemented, promise to eliminate barriers and increase girls' and women's participation in STEM.

Childhood and Adolescence: Barriers to STEM Engagement

Gender Role Stereotypes Conflict With STEM Stereotypes

Children learn about gender in early childhood as they encounter gendered roles and expectations (e.g., Eccles, Jacobs, & Harold, 1990). Feminine gender role stereotypes orient girls to be communal (e.g., socially skilled and helpful), focus on children and family, and gravitate toward activities that emphasize interpersonal relationships (Konrad, Ritchie, Lieb, & Corrigall, 2000). Masculine gender role stereotypes orient boys to be agentic (e.g., acquire mastery, skills, competence), explore the physical world, tinker, figure out how things work, and gravitate toward activities that emphasize problem solving, status, and financial gain. Masculine gender roles align with popular cultural representations of math and science, which are portrayed as unrelated to real-world concerns and not people-oriented (Buck, Leslie-Pelecky, & Kirby, 2002).

Consider mathematics as an example. American cultural messages associating mathematics with boys more than girls are everywhere (National Science Foundation [NSF], 2003). American children as young as 6 to 7 absorb these stereotypes, and by age 10, girls like math less than reading (Herbert & Stipek, 2005); however, performance differences emerge later in adolescence (Hyde, Fennema, & Lamon, 1990). In sum, gender differences in children's awareness of math stereotypes and internalization of those stereotypes happen *before* the emergence of test performance differences.

Parents Influence Children's STEM Interest

Parent expectations socialize children's academic trajectories: The more parents encourage their children's after-school STEM activities, provide activity-related materials, and participate with them, the more children become interested in STEM (Simpkins, Davis-Kean, & Eccles, 2006). Parents' beliefs about their children's math ability and effort better predict children's confidence in math than children's actual math grades (Frome & Eccles, 1998). In middle and high school, mothers' (more than fathers') support predicts adolescent girls' motivation to persist in science and math (Leaper, Farkas, & Brown, 2012). On the downside, on average, mothers apply gender stereotypes about math and science to their children more than fathers do (Yee & Eccles, 1992). In sum, parents are critical early socializers of their children's academic interests.

Peers Influence Children's STEM Interest

Peer acceptance is a central concern in adolescence (Eaton, Mitchell, & Jolley, 1991), and same-sex friends' interest influences adolescent girls' pursuit of STEM. Nationally representative samples from middle to high school showed that students' decisions to take advanced math and physics classes were linked to their friends' course-taking the previous year. Specifically, girls' decisions to take advanced math and physics courses were predicted by how well their *female* (not male) friends did in these classes the previous year (Riegle-Crumb, Farkas, & Muller, 2006). Boys' friends were less likely to influence their course-taking decisions.

Peers also influence classroom climate, which then affects students' persistence in STEM. Collaboration is particularly important; when students exchange ideas, they justify their own position, gain exposure to other ways of thinking, and experience self-confidence, mastery, and successful task completion (Durik & Eccles, 2006; Patrick, Ryan, & Kaplan, 2007; Ryan & Patrick, 2001). Collaboration is particularly helpful for girls in math, as they show more interest, better grades, and stronger math aspirations in collaborative environments than do boys (Wang, 2012). On the flip side, competition among students is less conducive to learning, self-efficacy, and achievement (Ames, 1992; Dweck & Leggett, 1988).

Personal Goals and Values Enhance STEM Education

Students find STEM courses more meaningful when they connect classroom experiences with personal goals (Gentry & Owen, 2004). Personally relevant academic tasks enhance motivation, attention, learning, and task identification (Hidi & Harackiewicz, 2000). For example, when students learn math via hands-on projects, rather than abstract instruction, they view the subject as more interesting and personally meaningful (Mitchell, 1993). Importantly, girls are more interested in math instruction taught from an applied perspective than boys (Geist & King, 2008; Halpern, 2004).

Specific values (e.g., money, power, altruism, family focus) are associated with specific occupations. Starting in adolescence (ages 11-17) and moving into adulthood, gender differences start emerging in occupational values (Eccles, 1994). Whereas boys and men value money, power, achievement, challenge, and risk taking, girls and women emphasize altruism, interpersonal orientation, family time, and knowledge development (Eccles, 1994; Konrad et al., 2000; Post-Kammer, 1987). STEM fields are (mis)perceived to impede communal goals whereas service professions (social work, nursing, teaching, human resource) are perceived to facilitate communal goals (Diekman, Brown, Johnston, & Clark, 2010). Because communal goals interest females more than males (Su, Rounds, & Armstrong, 2009), the seeming lack of it between these goals and STEM stereotypes make females move away from STEM careers. Stereotypes about STEM are clearly inaccurate—physical and life sciences, engineering, and technology involve intense collaboration within teams and are critical to solving real-world problems that help people and society. However, children and adolescents are unaware of communal values inherent in STEM occupations.

Evidence-Based Solutions: Recommended Programs and Practices for Girls

The research described above shows why girls move away from STEM in middle and high school and in so doing, hints at how to turn the tide. We use the research above to identify four types of programs and practices that promise to broaden the STEM pipeline in K-12 environments.

Foster Collaborations Between K-12 Schools and Science Museums

Collaboration between K-12 schools and science and technology museums provides opportunities to link abstract concepts learned in classrooms to real-world applications displayed in museums in ways that are experientially engaging and audiovisual. Museum examples demonstrate how science and technology improve people's lives, solve real-world problems, and require collaboration—thereby highlighting STEM's communal and altruistic aspects. To be most effective, visits to science museums must be in sync with students' STEM curriculum.

Foster Collaborations Between K-12 Schools and STEM Departments in Colleges and Universities

Relationships between higher education and K-12 schools bring children and adolescents face-to-face with real scientists, engineers, and technology creators who are faculty and graduate students in STEM departments. Colleges and university administrators, as well as school principals and superintendents, should reward such collaborative efforts. Funding agencies should recognize outreach, offering small grant support. A successful example is the NSF's CAREER award, which explicitly requires successful grant proposals to do more than demonstrate excellent scientific merit. The Principal Investigator (PI) must also demonstrate how the proposed project will have a "broader impact." One way to achieve broader impact involves grant-related activities aimed at attracting children and adolescents in elementary, middle, and high school into STEM. This might involve PIs bringing young people into the lab for scientific demonstrations, giving a science workshop at a local school, or collaborating with the science teacher to organize a relevant field trip. The goal is to create opportunities for STEM faculty to visit K-12 classes and talk about their research in age-appropriate and interesting ways, so that young people can see concrete examples of what scientists and engineers do and meet real scientists and engineers, especially women. At least 50% of these visitors should be *female* scientists, engineers, and graduate students from STEM programs, given that female students are positively influenced by female role models in STEM (Dasgupta, Hunsinger, & Scircle, 2014; Stout, Dasgupta, Hunsinger, & McManus, 2011; for a review, see Dasgupta, 2011).

Create Informal STEM Learning Environments, After-School Activities, and Summer Camps

Parent involvement includes exposing their children and adolescents to enrichment activities outside school, which open up opportunities to explore science and technology through "doing" (coding clubs, robotics clubs, science–art summer camps). By emphasizing creativity and hands-on activity, with grades off the table, these activities allow girls to explore science and technology as hobbies not linked to academics. For example, teaching children to code allows them to communicate their ideas using computer programs and bringing those ideas to life in creative ways by building a new app, designing code-assisted art, making wearable fashion, or building a robot to help with a real-world problem. To attract girls, the activities must leverage girls' existing interests. Writing code to create a robot may interest some girls, but not others; whereas writing code to create music, art, or a medical device may interest a different subset of girls. Informal STEM activities attract girls when the activities are communally oriented—that is, organized around real-world problems and helping people (Diekman et al., 2010). When extracurricular projects in STEM involve teamwork, girls are most eager and participatory in teams that have gender parity (50% girls) or a female majority and far less engaged in teams with female minorities (25% or less; Dasgupta, Scircle, & Hunsinger, 2014). These types of extracurricular activities should involve female techies, engineers, and scientists because their presence illustrates to girls who they could become in the future.

Emerging Adulthood: Barriers to STEM Engagement

Once girls develop an interest in STEM, what blocks retention and advancement through higher education in STEM? And what can dismantle those barriers? Once women make it to college, they are bombarded with subtle (and not so subtle) messages that signal they do not belong in STEM career tracks, especially physical sciences, computer science, engineering, and mathematics. Doubts about belonging, in turn, hinder women's achievement, engagement, and persistence in STEM majors by making them question whether their abilities, interests, and aspirations are compatible with STEM. One way to enhance women's sense of belonging is by changing the social environment within STEM majors.

The Primacy of Belonging and Women's Lack of Fit

For decades, social psychological research has noted the fundamental importance of feeling accepted and welcome (i.e., a sense of *belonging*) for human psychological well-being (Baumeister & Leary, 1995). Applied to learning environments, when students do not feel that they belong in an academic setting, they become disengaged and unmotivated, resulting in low academic performance (Freeman, Anderman, & Jensen, 2007). Feeling out of place is especially common in STEM fields such as computer science, engineering, and the physical sciences (Cheryan, Plaut, Davies, & Steele, 2009; Murphy, Steele, & Gross, 2007; Stout et al., 2011), and is associated with lower performance and thoughts about leaving the field. A big reason why women feel out of place in STEM is because of the widespread stereotype that STEM fields such as physical sciences, technology, math, and engineering are "guy things" (e.g., Nosek, Banaji, & Greenwald, 2002). Women who believe this stereotype tend to underperform in math-intensive fields (Miyake et al., 2010) and feel a lower sense of belonging (Stout, Ito, Finkelstein, & Pollock, 2013). Lower belonging leads to greater attrition. Thus, awareness of the STEM-is-male stereotype can become a self-fulfilling prophecy. Where do the stereotypes originate?

Women Are Outnumbered by Their Male Peers

In college STEM classes, men typically outnumber women by at least 3:1. Given skewed gender ratios, female students often find themselves to be one of a few women (i.e., a "token") or the only woman (i.e., a "solo") in a class or team. Being a token or solo makes people feel overly visible, "boxed in" by stereotypes about their group, and pressured to perform well (Kanter, 1977). In one study (Murphy et al., 2007), women STEM majors watched one of two promotional videos of a research conference, showing different gender compositions of attendees. Relative to the video with a 1:1 gender ratio, women who watched the video with a 3:1 male-to-female ratio indicated that they expected to feel a lower sense of belonging at the conference and were less interested in attending.

Similarly, the gender composition of engineering teams affects female students' thoughts, feelings, and behavior during teamwork. One study found that female college students randomly assigned to teams where women were the minority (25%) were less confident and involved in teamwork, reported feeling more unsure and worried, and spoke less than female students assigned to teams where women were in the majority (75%; Dasgupta, Scircle, & Hunsinger, 2014).

Women Have Few Same-Sex Role Models and Mentors

Access to role models and mentors influences successful professional development. Young adults identify with successful female role models whose presence allows them to think: "If she can be successful, so can I" and "I want to be like her." Typically, however, female college students encounter few same-sex role models who are faculty in STEM departments. STEM faculty members (especially full professors in physical sciences and engineering) are 4 times more likely to be men than women (NSF, 2013). However, when STEM professors are female, their presence in classrooms has clear benefits for female students. For example, one study found female students taking college courses in calculus taught by female faculty (compared with male faculty) felt more confident about their math ability and viewed mathematics as central to their sense of self, which in turn increased their intentions to pursue STEM careers (Stout et al., 2011; also see Dasgupta, Hunsinger, & Scircle, 2014). Role models also serve as mentors who guide professional development, champion students' work, and broaden their professional network. A dearth of role models means undergraduate women are less likely to learn how to navigate the path from their first year in college to STEM careers, which involves the development of social capital necessary to persist in STEM.

Evidence-Based Solutions: Recommended Programs and Practices for Women in Emerging Adulthood

Stemming the leaky pipeline of women in STEM should emphasize two factors that increase social belonging—exposure to female experts and female peers. Such exposure acts as a "social vaccine" that inoculates women's self-concept against noxious stereotypes, builds resilience, and increases belonging (Dasgupta, 2011).

Promote Opportunities for Peer Networking

Because women are often tokens or solos in their academic departments, they need other venues to network, learn, and share peers' experiences. STEM departments should support programs that help foster a sense of belonging among women in STEM, and encourage female students to attend diversity conferences and professional society meetings such as Society of Women in Engineering, which invest in students' success. In the computing field, the Anita Borg Institute hosts an annual conference specifically for women called the Grace Hopper Celebration of Women in Computing. The world's largest annual gathering of women in computing, this event provides a welcoming space for female students to network, present their work, and receive mentoring from female computing experts.

Provide Role Models and Mentorship for Women

Academic departments should recruit senior women in STEM fields to present their technical work as part of department colloquia, brown-bags, and other special events, providing opportunities for these speakers to meet and mentor students. For example, the Distributed Lecture Series sponsored by the Computing Research Association sends female faculty and technical researchers in industry to university campuses as female role models. Their campus visits include a technical talk and networking events. The Computing Research Association subsidizes these visits.

Professional Life: Barriers to Advancement in STEM Careers

Once women have made it through STEM graduate training and seek to enter and advance in STEM careers, different barriers emerge. The first barrier is the hiring stage. Second, once hired, the professional and social climate in some academic departments may be less than inclusive, with impediments to tenure and promotion. Third, during the years toward tenure and promotion, women's struggle to balance work and family responsibilities, especially caregiving of young children, has a major impact on their career arc.

Gender Bias in Hiring and Promotion

Merit and equal opportunities are mainstays of American culture. Yet, these values do not always appear in hiring for STEM research jobs. Even when applicants' qualifications are identical, male applicants are often hired over female applicants. In one study, faculty in various science departments at U.S. research universities evaluated the resume of a male or female candidate for a lab manager position. The resumes were identical except for the candidate's first name, which indicated gender. Faculty members evaluated the male candidate as more competent and hirable, more worthy of mentoring, and deserving a higher salary than the female candidate (Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012). Both male and female faculty showed gender bias in hiring and were unaware of their bias.

Another hiring barrier comes from letters of recom-mendation. Gender stereotypes linking ideal scientists with maleness affect what attributes recommendation letters emphasize. Recommendation letters for faculty positions typically emphasize multiple strengths—research, teaching, service, and personal qualities. An archival study analyzed recommendation letters for 312 male and female job applicants applying for faculty positions at medical schools (Trix & Psenka, 2003); most letter writers were male. Letters portrayed male applicants as more serious researchers than female applicants. Research skills, publications, and career aspirations appeared more frequently in letters for male applicants, whereas teaching skills, practical clinical skills, and personal attributes appeared more frequently in letters for female applicants. Given the jobs were in biomedical research, recommendation letters emphasizing research, publications, and career aspirations likely made the male applicants more desirable candidates than their female peers.

The gender stereotype that women (more than men) ought to be warm and likeable differentially affects how professional women are evaluated for promotions and professional rewards. Women who violate the warmth stereotype are disliked more than men who behave identically. Being seen as not warm hurts women's chances of promotions and professional rewards, but it does not affect men (Rudman & Glick, 2001). This is especially likely when individuals are being considered for professional leadership roles (Eagly & Karau, 2002). For women to be successful, they have to be highly competent and also warmer and more likeable than their male colleagues. Competence by itself is not enough for success. In sum, gender stereotypes function as invisible barriers to women in STEM professions, even if they have the same qualifications as their male peers.

Evaluation of Scientific Work

Gender bias in evaluations also creeps into peer reviews of scientific work, such as manuscripts submitted to journals and grant proposals submitted to granting agencies. One study examined peer-review scores given by scientific review panels in Sweden to PIs applying for post-doctoral grants and found that the peer-reviewing process was riddled with gender bias and nepotism (Wenneras & Wold, 1997). The authors obtained the scientific competence scores given to each grant proposal by peer reviewers on the scientific review panel. This score determined grant funding. They then compared these subjective ratings with the PIs' objective scientific productivity based on their total publication record (e.g., first-authored publications, impact factor of journals in which the PI had published, etc.). On comparing the objective productivity index of each PI with the subjective scientific competence scores given by reviewers, results showed that even when the objective productivity of female and male PIs was identical, peer reviewers evaluated the female PIs as less scientifically competent than male PIs, which decreased their chance of getting the grant.

Department Climate

As noted earlier, a feeling of belonging in academic and professional life is the psychological glue that keeps people invested in their academic institutions and departments. Women are less likely than men to feel a sense of belonging in STEM departments (National Research Council, 2009). They are more likely to feel isolated and lack camaraderie, feel excluded from informal social gatherings and some formal ones too, report fewer opportunities to collaborate with senior faculty on research and teaching, and feel that the treatment of junior faculty is not equal and fair (Massachusetts Institute of Technology, 1999; Rosser, 2004). Junior faculty who are women are also more likely to report inadequate professional mentoring (Rosser, 2004) and inadequate institutional support for having a family while on tenure track (Hill, Corbett, & St. Rose, 2010).

Work–Family Balance

Parenting young children affects women's STEM careers (Mason & Goulden, 2002). Family responsibilities and departments' work–life policies have a bigger effect on the job satisfaction of female than male faculty, given that women do more caregiving for young children and elders than do men. Juggling caregiving is compounded by the fact that most universities do not provide child care. Caregiving responsibilities curtail women's travel to conferences, where colleagues outside the home university can learn about their work. Absence from the conference and invited talk circuit, in turn, interferes with obtaining the international recognition necessary for promotion to full professor. A recent retention study found that women more than men are more likely to cite family-related issues and time as a reason for leaving STEM careers (Frehill, Di Fabio, Hill, Trager, & Buono, 2008). A different work–family dilemma comes from women being more likely than men to have a partner who is also in a STEM career, creating a "two-body problem" in job searches. When this happens men's careers are often given priority over women's (Wolf-Wendel, Twombly, & Rice, 2003).

Return to STEM Careers After a Pause

Some women take a break from their post-PhD career for caregiving, with the intention of re-entering the academic career track later (Mason & Goulden, 2002). However, several factors conspire to hinder returning to STEM labor markets (Mavriplis, Heller, Sorensen, & Snyder, 2005). One inhibiting factor is that women's networks with professional communities weaken over time during their absence from the field. Second, career gaps are judged too deviant from the prototypical career arc, where one moves directly from a PhD program to a post-doctoral fellowship to a full-time academic research position. The absence of visible successful examples of non-linear careers in STEM makes it difficult to imagine going against the tide. Third, during a pause in their career trajectory, women may become rusty in some skills needed to secure academic jobs. In the absence of mechanisms that help refresh these skills and rebuild confidence, entering the on-ramp to a research career is daunting.

Evidence-Based Solutions: Recommended Programs and Practices for Professional Life

Conduct Blind Review of Applications and Other Work Products

To the degree that search committees are able, they should strive to mask each applicant's identity (gender, race). De-identifying applicants has been hugely successful and increased gender diversity in other fields, such as professional orchestras. Historically, professional orchestras suffered from low gender diversity, but this changed after the method of auditioning was modified—now, a screen separates the auditioning musician from the judges. This simple practice dramatically increased the number of female musicians hired based on their audition performance (Golden & Rouse, 2000). In academic jobs, such a strategy is not feasible for on-campus interviews. However, gender-blind review of applications may be possible in the initial review stage when search committees create "shortlists." De-identified evaluations are also important for other work products such as submitted manuscripts and grant proposals. Many journals and grant funders already use blind reviews, but others do not.

Foster an Inclusive Climate in STEM Departments

Given the importance of belonging, universities should periodically assess climate within departments in order to detect systematic disparities in faculty experiences. Professional climate predicts job satisfaction and attrition more for female than male faculty. Fostering an inclusive environment can encourage research or teaching collaborations between junior and senior faculty, increase professional and personal interactions, and reduce professional isolation experienced by new faculty. Departments could incentivize mentoring and encourage senior faculty to take interest in junior colleagues' professional development. Mentoring programs should be monitored and evaluated for effectiveness.

Alternative mentoring models go beyond one-to-one matching of senior and junior faculty. For example, in some universities, mentoring networks have spontaneously popped up, where female STEM faculty connect with each other across departments and meet for periodic lunches (Daniell, 2006). These distributed networks foster camaraderie, allowing faculty in similar departments to discuss work, share experiences, and get advice. Another model is "mutual mentoring," where a few faculty (at all career stages) meet around specific professional development topics funded by their home university.

Federal funding agencies have made some successful efforts to address the leaky pipeline problem. For example, the NSF's ADVANCE grants for institutional transformation provide large grants to identify and overcome barriers faced by women and other underrepresented STEM faculty. Continuing the NSF ADVANCE initiative is important, so that its benefits can filter across more universities.

Support Work–Life Balance for STEM Faculty

Effective policies allow STEM faculty to balance work and family responsibilities. These include stopping faculty tenure clocks for a year to accommodate childbirth, adoption, eldercare, and other caregiving responsibilities. Another policy offers 6 to 12 months paid leave for family emergencies. If these policies are instituted, universities should ensure that personnel committees not penalize faculty for reduced productivity during the leave period. A third family-friendly program would be funding on-campus child care facilities for faculty.

Professional Development

Often, women deal with professional barriers as individuals, handling them on an ad hoc basis. Professional societies and universities could provide structured professional development opportunities, so women can anticipate some of these barriers, plan how to navigate them, and predict important decision points. In some fields, career mentoring workshops provide support at professional society meetings. These workshops occur during major technical conferences making attendance easier because they piggy-back on key professional meetings.

Help Women Transition Back Into STEM Research Careers After a Break

For women who have taken time off research careers to take care of family needs, the way to transition back is often unclear. Societies' networking events could bring together women seeking to return to research careers and other STEM researchers to promote information sharing, create new contacts, and renew old ones. Women who had taken time off but who participated in such workshops reported much more confidence in these professional development areas than others who had not participated (Mavriplis et al., 2005). Other practices, such as reduced fees for society membership and conference registration, would allow women seeking reentry to attend conferences and re-engage in their field, as a way of mitigating isolation, getting up-to-speed on new research, and making concrete plans to return to an academic career.

Conclusion

No single cause creates the leaky pipeline of girls and women from STEM fields, so no single magic bullet will solve the problem. At various life stages, distinct social-psychological factors create or magnify the leaky pipeline. Two themes are common to all developmental stages. First, culturally ubiquitous stereotypes consistently portray ideal scientists, engineers, and technology innovators as male. The mismatch between masculine STEM stereotypes and feminine gender role expectations creates barriers for girls' and women's participation in STEM at every life stage. A second common theme across all life stages is feelings of belonging in one's intellectual community. Learning environments and professional environments that foster belonging are far more likely to be successful in recruiting, retaining, and advancing girls and women in STEM than environments that feel more exclusive and homogeneous. At each life stage, evidence-based programs, practices, and policies can keep girls and women engaged in STEM. Multiple interventions targeting all three stages of development promise to eliminate gendered barriers and increase female participation, motivation to succeed, and aspirations in STEM.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The research for and writing of this article were funded by an NSF CAREER award (BCS 0547967, PI: Dasgupta) and NSF GSE 1132651 (PI: Dasgupta).

References

Ames, C. (1992). Classrooms: Goals, structures, and student motivation. *Journal of Educational Psychology*, *84*, 261-271.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*, 497-529.

Buck, G. A., Leslie-Pelecky, D., & Kirby, S. K. (2002). Bringing female scientists into the elementary classroom: Confronting the strength of elementary students' stereotypical images of scientists. *Journal of Elementary Science Education*, *14*, 1-9.

Cheryan, S., Plaut, V. C., Davies, P. G., & Steele, C. M. (2009). Ambient belonging: How stereotypical cues impact gender participation in computer science. *Journal of Personality and Social Psychology*, *97*, 1045-1060.

Daniell, E. (2006). *Every other Thursday*. New Haven, CT: Yale University Press.

Dasgupta, N. (2011). Ingroup experts and peers as social vaccines who inoculate the self-concept: The stereotype inoculation model. *Psychological Inquiry*, *22*, 231-246.

Dasgupta, N., Hunsinger, M., & Scircle, M. (2014). *Stereotype inoculation in adolescence: The effect of teacher gender on adolescents' academic self-concept and beliefs about science*. Unpublished manuscript, University of Massachusetts Am-herst.

Dasgupta, N., Scircle, M., & Hunsinger, M. (2014). *The effect of peers on women in engineering*. Unpublished manuscript, University of Massachusetts Amherst.

Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2010). Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science*, *21*, 1051-1057.

Durik, A. M., & Eccles, J. S. (2006). Classroom activities in math and reading in early, middle, and late elementary school. *Journal of Classroom Interaction*, *41*, 33-41.

Dweck, C. S., & Leggett, E. L. (1988). A social–cognitive approach to motivation and personality. *Psychological Review*, *95*, 256-273.

Eagly, A. H., & Karau, S. J. (2002). Role congruity theory of prejudice toward female leaders. *Psychological Review*, *109*, 573-598.

Eaton, Y. M., Mitchell, M. L., & Jolley, J. M. (1991). Gender differences in the development of relationships during late adolescence. *Adolescence*, *26*, 565-568.

Eccles, J. S. (1994). Understanding women's educational and occupational choices. *Psychology of Women Quarterly*, *18*, 585-609.

Eccles, J. S., Jacobs, J. E., & Harold, R. D. (1990). Gender role stereotypes, expectancy effects, and parents' socialization of gender differences. *Journal of Social Issues*, *46*, 183-201.

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin*, *136*, 103-127.

Freeman, T. M., Anderman, L. H., & Jensen, J. M. (2007). Sense of belonging in college freshmen at the classroom and campus levels. *Journal of Experimental Education, 75*, 203-220.

Frehill, L. M., Di Fabio, N., Hill, S., Trager, K., & Buono, J. (2008, summer). Women in engineering: A review of the 2007 literature. *SWE Magazine*, *54*(3), 6-30.

Frome, P. M., & Eccles, J. S. (1998). Parents' influence on children's achievement-related perceptions. *Journal of Personality and Social Psychology*, *74*, 435-452.

Geist, E. A., & King, M. (2008). Different, not better: Gender differences in mathematics learning and achievement. *Journal of Instructional Psychology*, *35*, 43-52.

Gentry, M., & Owen, S. V. (2004). Secondary student perceptions of classroom quality: Instrumentation and differences between advanced/honors and nonhonors classes. *Journal of Advanced Academics*, *16*, 20-29.

Golden, C., & Rouse, C. (2000). Orchestrating impartiality: The impact of "blind" auditions on female musicians. *The American Economic Review*, *90*, 715-750.

Halpern, D. F. (2004). A cognitive-process taxonomy for sex differences in cognitive abilities. *Current Directions in Psychological Science*, *13*, 135-139.

Herbert, J., & Stipek, D. T. (2005). The emergence of gender differences in children's perceptions of their academic competence. *Journal of Applied Developmental Psychology*, *26*, 276-295.

Hidi, S., & Harackiewicz, J. M. (2000). Motivating the academically unmotivated: A critical issue for the 21st century. *Review of Educational Research*, *70*, 151-179.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. Washington, DC: American Association of University Women.

Hyde, J. S., Fennema, E., & Lamon, S. J. (1990). Gender differences in mathematics performance: A meta-analysis. *Psychological Bulletin*, *107*, 139-155.

Kanter, N. (1977). *Men and women of the corporation*. New York, NY: Basic Books.

Konrad, A. M., Ritchie, J. E., Lieb, P., & Corrigall, E. (2000). Sex differences and similarities in job attribute preferences: A meta-analysis. *Psychological Bulletin*, *126*, 593-641.

Leaper, C., Farkas, T., & Brown, C. S. (2012). Adolescent girls' experiences and gender-related beliefs in relation to their motivation in math/science and English. *Journal of Youth and Adolescence*, *41*, 268-282.

Mason, M. A., & Goulden, M. (2002). Do babies matter? The effect of family formation on the lifelong careers of academic men and women. *Academe*, *88*(6), 21-27.

Massachusetts Institute of Technology. (1999). *A study of the status of women faculty in science at MIT*. Cambridge: School of Science, Committee on Women Faculty, Massachusetts Institute of Technology.

Mavriplis, C., Heller, R., Sorensen, C., & Snyder, H. D. (2005, June). *The FORWARD to professorship workshop*. Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition, American Society for Engineering Education.

Mitchell, M. (1993). Situational interest: Its multifaceted structure in the secondary school mathematics classroom. *Journal of Education Psychology*, *85*, 424-436.

Miyake, A., Kost-Smith, L. E., Finkelstein, N. D., Pollock, S. J., Cohen, G. L., & Ito, T. A. (2010). Reducing the gender achievement gap in college science: A classroom study of values affirmation. *Science*, *330*, 1234-1237.

Moss-Racusin, C. A., Dovidio, J. F., Brescoll, V. L., Graham, M. J., & Handelsman, J. (2012). Science faculty's subtle gender biases favor male students. *Proceedings of the National Academy of Sciences of the United States of America*, *109*, 16474-16479.

Murphy, M., Steele, C. M., & Gross, J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science*, *18*, 879-885.

National Academies. (2010). *Rising above the gathering storm, revisited: Rapidly approaching Category 5*. Washington, DC: National Academies Press.

National Center for Education Statistics. (2013). *Digest of education statistics*. Washington, DC. Retrieved from http://nces.ed.gov/programs/digest/d13/tables/dt13_318.10.asp

National Research Council. (2009). *Gender differences at critical transitions in the careers of science, engineering, and mathematics faculty*. Washington, DC: National Academies Press.

National Science Foundation. (2003). *New formulas for America's workforce: Girls in science and engineering* (Publication No. 03-207). Arlington, VA: Author.

National Science Foundation. (2013). Women, minorities, and persons with disabilities in science and engineering: Women as a percentage of full-time, full professors with science, engineering, and health doctorates, by institution of employment: 1993-2010. Retrieved from http://www.nsf.gov/statistics/wmpd/2013/digest/theme5.cfm

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Math = male, me = female, therefore math ≠ me. *Journal of Personality and Social Psychology*, *83*, 44-59.

Patrick, H., Ryan, A. M., & Kaplan, A. (2007). Early adolescents' perceptions of the classroom social environment, motivational beliefs, and engagement. *Journal of Educational Psychology*, *99*, 83-98.

Post-Kammer, P. (1987). Intrinsic and extrinsic work values and career maturity of 9th-and 11th-grade boys and girls. *Journal of Counseling & Development*, *65*, 420-423.

Riegle-Crumb, C., Farkas, G., & Muller, C. (2006). The role of gender and friendship in advanced course taking. *Sociology of Education*, *79*, 206-228.

Rosser, S. V. (2004). *The science glass ceiling: Academic women scientists and the struggle to succeed*. New York, NY: Routledge.

Rudman, L. A., & Glick, P. (2001). Prescriptive gender stereotypes and backlash toward agentic women. *Journal of Social Issues*, *57*, 743-762.

Ryan, A. M., & Patrick, H. (2001). The classroom social environment and changes in adolescents' motivation and engagement during middle school. *American Educational Research Journal*, *38*, 437-460.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology*, *42*, 70-83.

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *Journal of Personality and Social Psychology*, *100*, 255-270.

Stout, J. G., Ito, T. A., Finkelstein, N. D., & Pollock, S. J. (2013, January). *How women's endorsement of gendered science stereotypes contributes to the gender gap in STEM participation*. Presentation at the annual meeting of the Society for Personality and Social Psychology, New Orleans, LA.

Su, R., Rounds, J., & Armstrong, P. I. (2009). Men and things, women and people: A meta-analysis of sex differences in interests. *Psychological Bulletin*, *135*, 859-884.

Trix, F., & Psenka, C. (2003). Exploring the color of glass: Letters of recommendation for female and male medical faculty. *Discourse & Society*, *14*, 191-220.

Wang, M.-T. (2012). Educational and career interests in math: A longitudinal examination of the links between classroom environment, motivational beliefs, and interests. *Develop-mental Psychology*, *48*, 1643-1657.

Wenneras, C., & Wold, A. (1997). Nepotism and sexism in peer review. *Nature*, *387*(6631), 341-343.

Wolf-Wendel, L., Twombly, S., & Rice, S. (2003). *The two-body problem: Dual-career-couple hiring practices in higher education*. Baltimore, MD: Johns Hopkins University Press.

Yee, D. K., & Eccles, J. S. (1992). Parent perceptions and attribu-tions for children's math achievement. *Sex Roles*, *19*, 317-333.