AWIS
ASSOCIATION FOR WOMEN IN SCIENCE

Broadening Participation in Science, Technology, Engineering, and Mathematics

Surveying the Landscape

RESEARCHERS, policy makers, scientific funding agencies, companies, educational institutions and practitioners the world over have invested significantly in the recruitment of women into science, technology, engineering, and mathematics (STEM) fields over the past forty years. Understanding the status, however, requires a nuanced approach that recognizes differences in the nature and culture of the STEM disciplines and respective workplace environments. Some broad disciplinary fields, like the life sciences, have experienced higher levels of women's participation in terms of degree matriculation than others, like computing, where matriculation is actually declining. Worldwide, in fact, women represent less than 30% of engineers, physicists and computer scientists.

Much research points to the myriad stratification, cultural barriers, stereotypes, micro-aggressions, and biases women and people from historically underrepresented racial and ethnic backgrounds experience in STEM. These hindrances impact sense of scientific identity, self-efficacy, career choice, and fit. They also influence workload, hiring, space and resource allocation, salary and compensation package composition, evaluation, recognition and awards, research grant funding, promotion, tenure, access to key professional networks and mentors, movement into leadership roles, access to venture capital, startup funds, angel funds and core knowledge for scientific commercialization, and more.

Drawing data from 4,225 publishing scientists and researchers worldwide, the Association for Women in Science (AWIS) with support from the Elsevier Foundation, conducted the largest global survey ever undertaken about work/life integration issues among scientists (Dean & Koster, 2014). Survey respondents were working scientists and researchers who publish academically across all disciplines. Of the respondents, 80% were married or partnered, 70% were male, and 64% worked at a university. Thirty-six percent of respondents were from Western Europe, 24% were from the United States, 22% were from Asia Pacific, 6% were from Latin America and 6% were from Eastern Europe. The remaining 2% were from Africa and the Middle East.

Overall, results showed that lack of flexibility in the workplace, dissatisfaction with career development opportunities, and low salaries are driving both men and women to re-consider their profession. Less than three-fifths were happy with their work-life balance. Those who were happy successfully separate their work and personal lives, or are able to reduce their working hours or adopt flexible working hours [Figure I]. Those aged 56 and over were most happy (70%). Females were less likely than average to be happy with their work-life balance (52%) as were single respondents (51%) but having dependent children had no impact. Researchers in the UK and Germany were particularly unhappy with their work/life balance.

One-third of survey respondents reported a negative impact on career if striving for a good work/life balance. Agreement was higher among those with dependent children (36%), and particularly female researchers with children (46%). It was evident from verbatim comments that having family commitments limited ability to relocate for better research positions and that to be successful in research they had to be focused on their career. Those disagreeing noted there was no negative impact from having a good work/life balance or that it enhanced their career performance. Agreement was highest in the UK (39%), Canada (36%) and China (41%), but lowest in Italy (23%) and Brazil (13%). More than half of all scientists and researchers said that work demands conflict with their personal lives at least 2-3 times per week [Figure II].

In today's scientific workplace, multinational, dual-career couples are not unusual. Although women scientists select partners with similar qualifications, they report that they often put

About the Association for Women in Science

Founded in 1971, the Association for Women in Science (AWIS) is the largest multi-discipline organization for women in science, technology, engineering, and mathematics (STEM). AWIS is dedicated to driving excellence in STEM by achieving equity and full participation of women in all disciplines and across all employment sectors. We believe women in STEM should be:

- Compensated fairly and without discrimination;
- Advanced equitably and without bias;
- Respected and recognized for their scientific achievements;
- Exposed to successful role models in leadership positions; and
- Able to achieve optimum work life integration.

AWIS reaches more than 20,000 professionals in STEM with members, chapters, and affiliates worldwide. Our members work in more than 75 disciplines representing every branch of STEM. They are at all stages of their careers: from the bench to the board room, from basic research to application, from academia to corporate R&D, to the highest circles of policy-making.

For 45 years, AWIS has been driving positive change in systems and organizations through research based advocacy and action. Our advocacy and research portfolio is focused on positive workplace policies and practices, inclusive workforce development, and support for America's innovation enterprise. Tapping into America's full talent pool is essential to continued U.S. leadership in research and innovation.

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their own careers second and move professionally more often to support their partners' careers, often to the detriment of their own. Given that it is not uncommon for researchers to relocate for paid research positions, only a third of researchers responding to the survey agreed that their institute provided sufficient support for their spouse. Of those agreeing, some report that their institution has a spousal hire policy while others note that flexible working or benefit plans support their spouse. Those disagreeing (also 33%) indicate that their institution does not have a spousal hire policy or that such policies or other types of support are not available because of funding cuts. Agreement is lower than average in North America and Western Europe (28% each) while it is highest in the Asia Pacific Region (45%) and Latin America (42%). A quarter of respondents noted they would consider moving abroad to further their career. This was particularly the case for young (45% aged under 36) or single (41%) researchers as well as those specializing in hard sciences such as computer science (38%) and researchers in China (37%) and the Eurozone. Drivers of agreement were the expectation of more opportunities, funding, permanent positions available abroad. Agreement was notably low in the USA (13%).

More than one-third of female researchers have delayed having children in order to pursue their research career 39% of females agreed with this statement compared with 27% of males. Agreement also decreased with age. Those agreeing were waiting until they had a permanent position or noted that they could not afford to start a family on their current wage. Only a third of researchers agreed they work for family friendly institutions. Only 29% of scientists in the USA who responded said that their spouse or partner receives sufficient support from their institution. By comparison, 65% of Chinese scientists felt that their spouses or partners were receiving sufficient support.

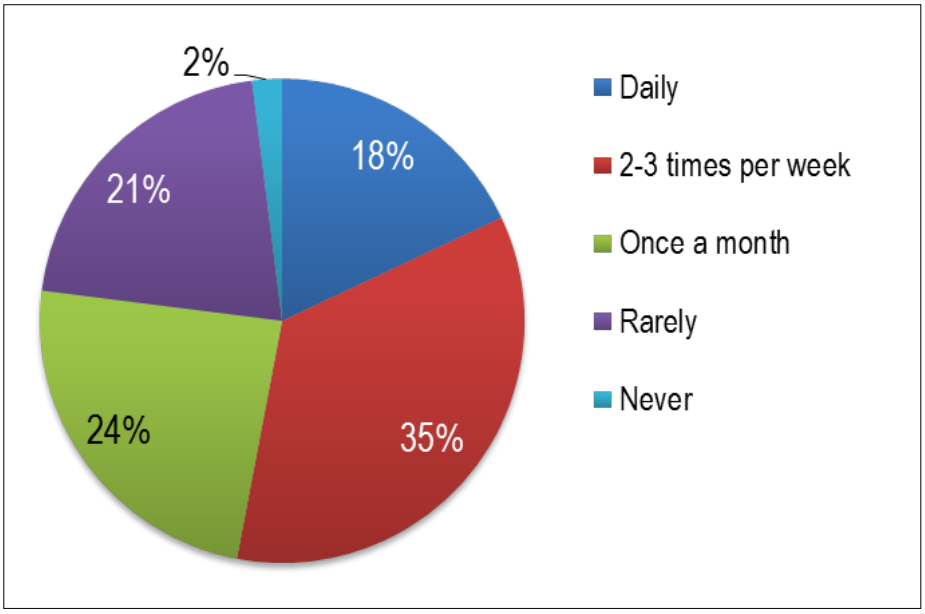


Figure 1.

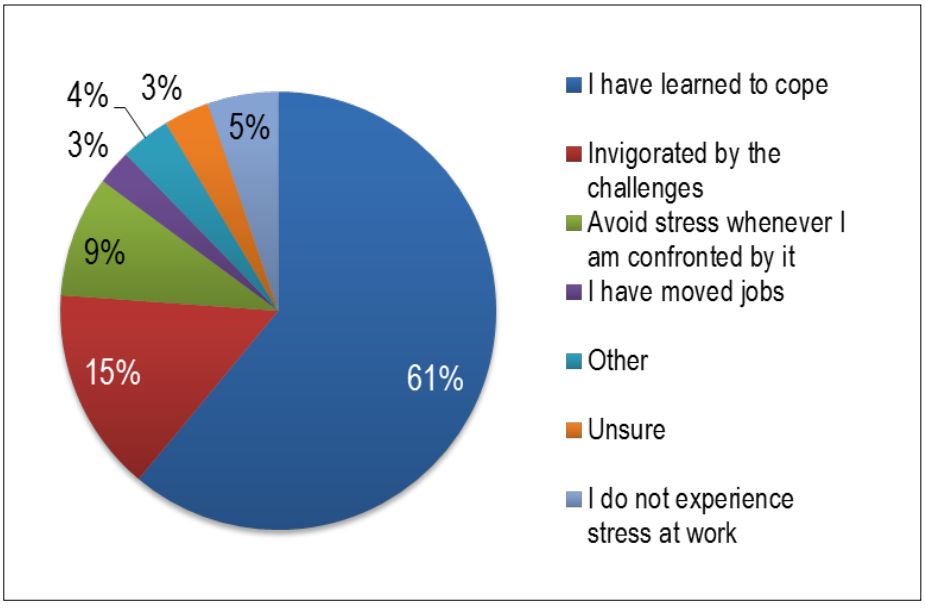


Figure 2.

Developing and sustaining a viable community of STEM professionals is a challenge faced not only by individual countries, but also by all national and regional participants in the global marketplace. As noted in the analyses above, countries and global regions mush recognize the necessity of increasing gender diversity and of developing policies that support full inclusion of both women and men in the STEM enterprise.

Obstacles to Creating Positive Workplace Environments

Underlying many of the struggles women in STEM endure, in both advancing their careers and finding time and energy for family life, is the issue of implicit bias. The body of literature committed to understanding why this seemingly negative quality has persisted is quite expansive especially with regard to workplace cultures. Research shows that organizations that see themselves as intensely meritocratic or data-driven, such as scientific research institutions and the technology sector, are actually more likely to show bias than organizations that don't hold a strong sense of meritocracy (Castilla & Bernard). This "paradox of meritocracy" makes it more difficult to address implicit bias in scientific workplaces as the idea that the best & brightest will be recognized and rewarded.

Understanding these biases and associations is also important because they have a chilling effect not just on efforts to recruit girls into science and engineering, but also on perceptions of women in these fields. These small associations manifest in big ways. Stereotype threat is the fear of performing poorly in a particular field where your gender or race is believed to be inferior, and thus reinforcing the stereotype (Steele & Aronson, 1995). Researchers who study stereotype threat have demonstrated that girls as young as nine start to integrate the messaging that "math is hard" and thus is probably something at which boys are better. Although these associations start young, they persist in our subconscious and impact decisions regarding hiring, promotion, and recognition, subsequently impacting the retention of women in STEM as well as other parts of the workforce.

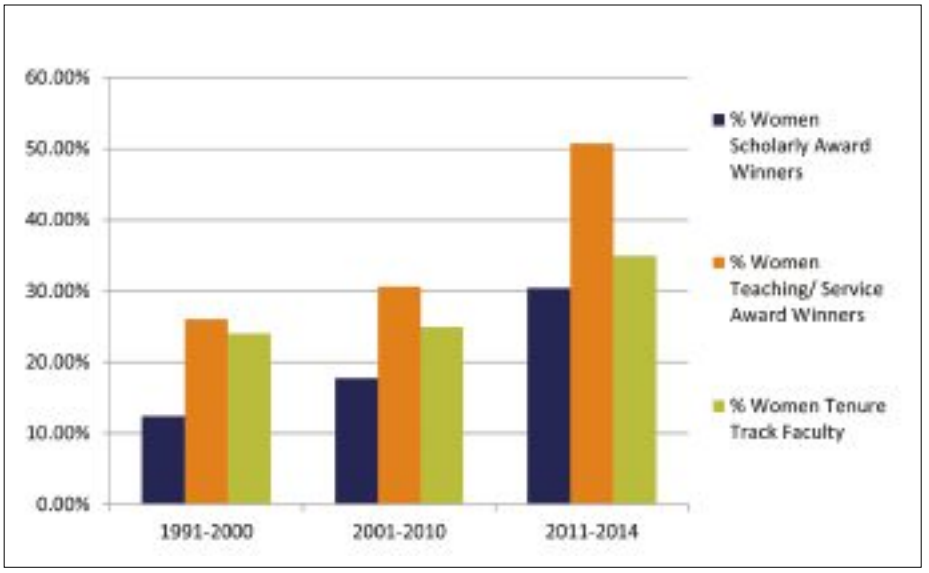
Recognizing Women's Scholarly Contributions

As mentioned above, a conscious worldview is not always sufficient to overcome implicit biases. Fortunately, studies show we can raise awareness and impact positive change on workplace cultures through delib-

erate and persistent interventions. As part of efforts to drive positive system change in STEM through research and advocacy, AWIS has conducted longitudinal research on awards allocations processes with 18 US-based STEM disciplinary societies with a combined membership of nearly 500,000 scientists and mathematicians.[1] Awards are external markers of achievement and recognition, and are important for job satisfaction and career advancement for recipients. However, marked gender disparities in rewards and recognition also contribute to a climate that hinders advancement of women and impairs their retention as STEM leaders.

Our research shows that while women's receipt of professional awards overall has increased in the past two decades, men win a higher proportion of scholarly awards and women win a higher proportion of teaching and service awards than expected based on their respective representation in the nomination pool. In addition, women won particularly few scholarly awards when there were "women only" awards available.

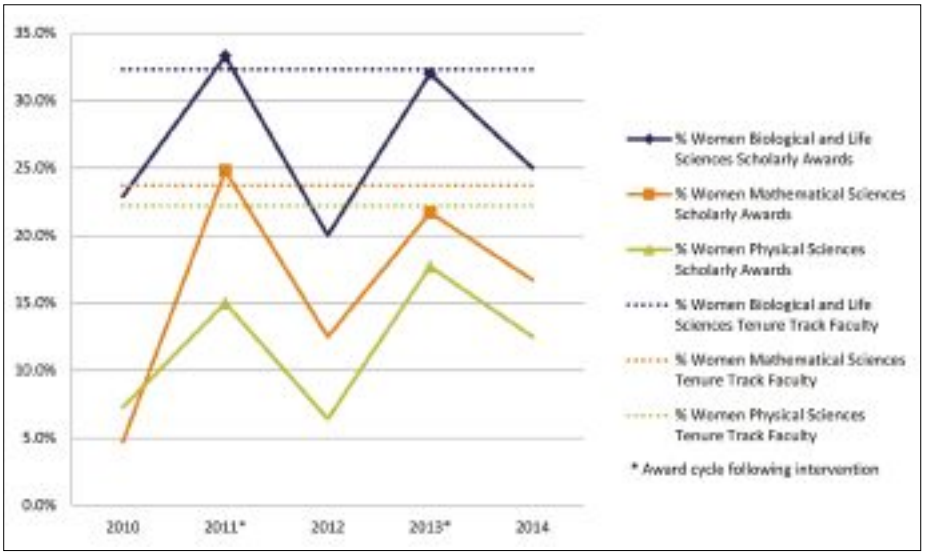
AWARDs® drew on our critical theoretical framework and research knowledge about stratification and bias in STEM recognition to conduct a quantitative analysis of the awards allocations by gender and award type. Through our study of the related research, we found that the pipeline narrative was present in this arena as well and was used to argue that equity in awards would occur over time as the recruitment efforts to fix the supply-side were presumed to one day manifest in more women working in STEM. To test this, we used several different baseline measures for the potential pool of award candidates, including the number of advanced degrees in the discipline, actual nominees, number of members in the society, and faculty in the discipline. We divided the awards into categories surrounding their value to STEM fields: research and scholarly awards are more highly valued and are connected more specifically to promotion and tenure outcomes while teaching and service awards are less valued and connected to the caregiving activities of the field. We performed an ordinary least squares regression analysis of the %age of women award winners over an award period lasting two decades. In so doing, we found that women received a significantly and disproportionately high number of teaching and service awards and a disproportionately low



Graph I. Women are consistently underrepresented among recipients of scholarly andresearch awards and overrepresented among recipients of teaching and serviceawards.

number of research and scholarly awards relative to their representation in each of the baselines [see Graph 1 for data on the Life Sciences awards from 1991-2014]. Our analysis revealed that, despite the growth in award recognition for women during this period, women received a relatively small %age of scholarly awards compared to teaching awards. Contrary to the pipeline assumption, this disparity actually grew in the 2000s as the growth of women's receipt of teaching and service awards outpaced the increase in scholarly awards they received.

In addition, social science research on recognition indicates research done by women is often overlooked in favor of that of men, which is more frequently seen as notable (Grunspan et al., 2016; Knobloch-Westerwick et al., 2013; Lincoln et al., 2012; Popejoy & Leboy, 2012; Rossiter, 1993). This is known as the Matilda Effect (Knobloch-Westerwick et al., 2013; Lincoln et al., 2012; Popejoy & Leboy, 2012; Rossiter, 1993). To test for this, we conducted logistic regression analyses for the odds that a man will win scholarly awards and found that men were more than eight times more likely to win scholarly awards than women when accounting for their proportion in the nomination pool and were twice as likely to win scholarly awards regardless of their representation in the nomination pool. We also found that the presence of women on the awards committee benefits women's odds of winning, but the benefit is erased if the committee is chaired by a man. These findings suggested that a large degree of bias was at play in the current awards allocation processes within the professional societies.



Graph II. Repeated and intentional efforts are necessary for sustainable and equitable change to be realized.

As part of our interventions and partnership with the professional societies, with the support and presence of the society and awards committee leadership, we then presented these findings as evidence that further action needed to take place. We shared the findings in conjunction with

1 The disciplinary societies include: American Astronomical Society, American Chemical Society, American Economic Association, American Geophysical Union, American Institute for Biological Sciences, American Mathematical Society, American Physical Society, American Society of Plant Biologists, American Statistical Association, Botanical Society of America, Ecological Society of America, Ecological Society of America, Entomological Society of America, Genetics Society of America, Sigma Xi, Society for Industrial and Applied Mathematics, and Society of Neuroscience.

unconscious bias trainings and further data gathering by the participants as a review of their processes. We then brainstormed, within the context of each society, how to make revisions toward systemic change. The kinds of changes included: continuing bias trainings, creating more diverse selection committees, revising the language in calls for awards nominations and in the selection criteria, and creating greater transparency.

Since our interventions occurred, it appeared as if some progress had been made. However, using the critical lens to revisit the data and consider the context of the timing of the interventions and to disaggregate the longitudinal data accordingly, we found a different pattern that speaks greatly to the limits of interventions on sustainable change [Graph 2]. These intervention periods occurred twice, with two years in between. In the award cycle immediately following our interventions, we found that the awards allocations became more equitable. But, between interventions, the progress gained had diminished substantially and then, after the second intervention, moved closer to equity again. This allowed us to see that even with the heavy involvement of the societies in reshaping their processes within their own organizational contexts, continued and repeated efforts toward establishing new cultural norms within the professional societies is necessary. Otherwise, as awards committees shift membership, leadership turns over and time constraints occur, committees will fall back on old and problematic patterns of behavior. Our ongoing work is exploring how to make these changes more sustainable, particularly in environments with relatively high turnover rates in leadership.

Impact on Innovation and Entrepreneurship in STEM

Small businesses, entrepreneurial activity and STEM commercialization in industry and academia play an increasingly vital role in economies around the world. Research highlights many continued gender disparities and a lack of understanding the overlapping gendered spaces of STEM and entrepreneurship. These gaps not only illustrate social welfare issues, but also signal considerable talent will continue to be left out of the STEM innovation enterprise.

While women's rate of patenting in the United States has increased from 2.7% of total patenting activity to 10.8% over the past 40 years, at present, 28.4% of men with STEM PhDs hold at least one patent compared to 15% of women with STEM PhDs (Blume-Kohout, 2014; Sugimoto et al., 2015). Participation in initial and repeated patenting also varies by discipline and institutional context. Within the biological and medical sciences in academia, 9.1% of female faculty members hold at least one patent, while 22.7% of male faculty members do. Sugimoto et al.'s analysis of United States Patent and Trade Office data found that women fractionally held approximately 11% of patents in university settings and 8% in firms (2015). They also found that while women's proportion of patents held was greater in university settings, the technological impact of these patents has the widest gender gap in academic settings.

Similarly, STEM men are engaged in entrepreneurial activities at higher rates than are STEM women. Across STEM fields, 7% of men with PhDs are engaged in entrepreneurial activities compared to 5.4% of women (Blume-Kohout, 2014). While the lack of "a pool" of STEM women is often claimed as the reason for gender gaps in entrepreneurship, AWIS research shows a complex relationship between organizational culture, training, rewards, and access. Yet, little is known about how these disparities influence and intersect with innovation and entrepreneurship.

To build a better knowledge base in this arena, AWIS launched a series of national dialogues at the nexus of gender and entrepreneurship designed to create new applied knowledge and develop evidence-based policies and practices. These Summits center on how we, as a society, can fuel innovative solutions to global challenges facing all our citizens with a focus on how to develop inclusive, fiscally-responsive systems to drive research excellence and feed long-term economic growth. Early best practice solutions include increasing the entrepreneurship training opportunities for graduate students and postdoctoral fellows, adopting policies that enable faculty to engage in entrepreneurial activities without penalizing their tenure success, and encouraging those whose disclosures or patent applications were rejected to reapply in the future.

Conclusions

Countries around the world face both a persistent challenge to women and a promising opportunity for advancing STEM. For the past several decades, the majority of efforts to address the low participation rates of women in STEM have focused solely on the recruitment of girls and women into existing STEM programs and workplaces with limited success. Our work suggests that until we address the overall structural, cultural and systemic issues within our STEM educational and work places, changes in participation are unlikely to occur even in the context of innovation and entrepreneurship.

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