



ANNUAL LITERATURE REVIEW
FIXING THE BROKEN RUNG
TALENT PULSE REPORT
ROUNDTABLE DISCUSSION
COMMUNITY COLLEGE PATHWAYS
DIVERSITY & THE PATENT PROCESS

STATE OF WOMEN
IN ENGINEERING 2020

MAGAZINE OF THE SOCIETY OF WOMEN ENGINEERS

DISMANTLING THE GLASS CEILING

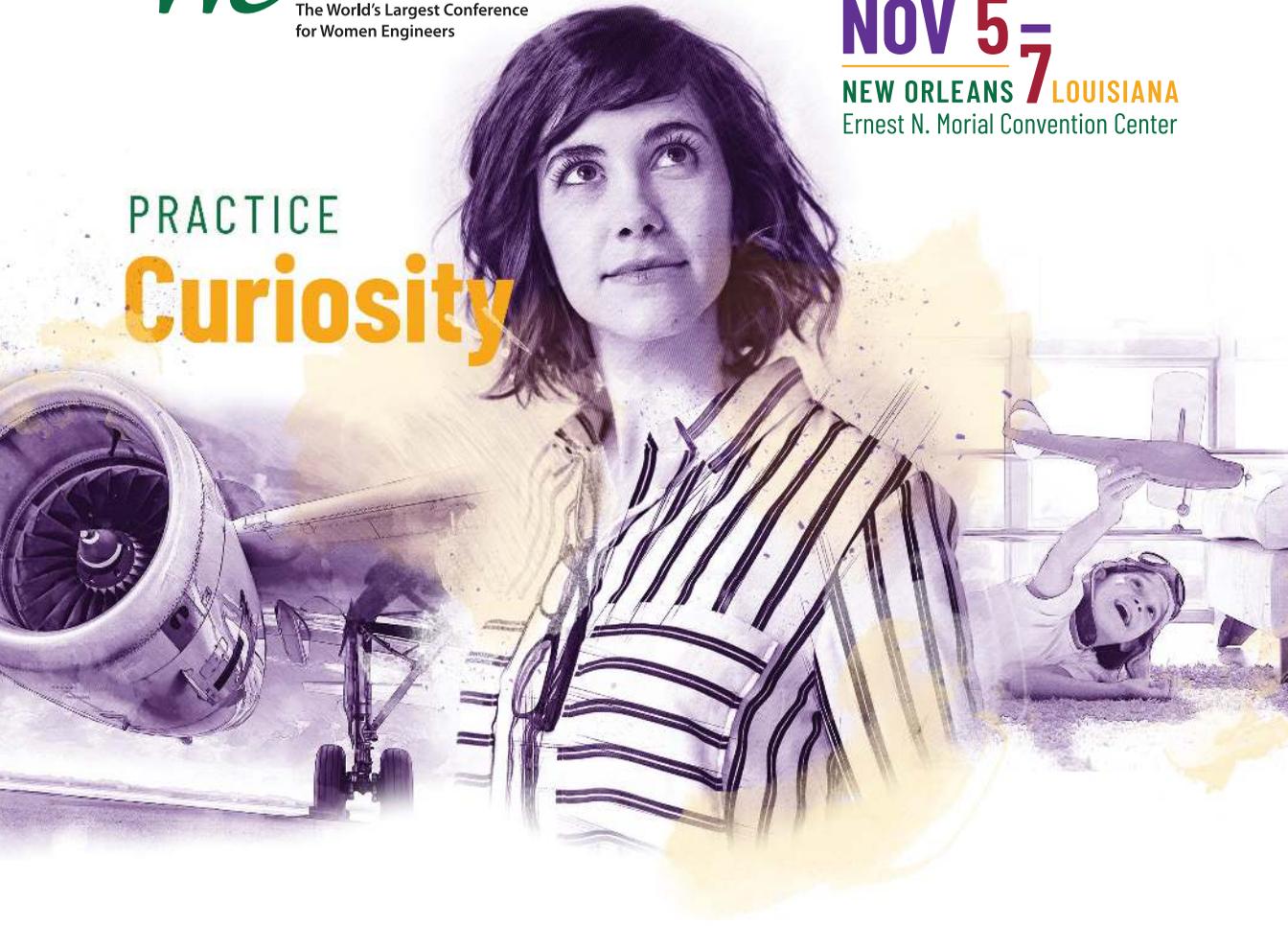
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Engage with *SWE Magazine* articles



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The Society of Women Engineers (SWE), founded in 1950, is a not-for-profit educational and service organization. SWE is the driving force that establishes engineering as a highly desirable career aspiration for women. SWE empowers women to succeed and advance in those aspirations and be recognized for their life-changing contributions and achievements as women engineers and leaders.

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Dismantling the Glass Ceiling



The term “glass ceiling” has been in use for more than 40 years. This metaphor for the invisible, structural barriers that impede women’s progress and mobility aptly describes the situation women

continue to face, particularly in engineering, despite incremental progress that has been made over decades of effort.

Reflecting on how she came to coin the term, management consultant and writer Marilyn Loden told the BBC that it happened while participating in a panel discussion at a 1978 conference. Listening to panelists who emphasized women’s “deficiencies” as the reason for lack of advancement, she said, “It was a struggle to sit quietly and listen to the criticisms.” When her turn came, “I argued that the ‘invisible glass ceiling’ — the barriers to advancement that were cultural not personal — was doing the bulk of the damage to women’s career aspirations and opportunities” (www.bbc.com/news/world-42026266).

Indeed, *SWE Magazine’s* yearly State of Women in Engineering issue is an exploration of the structural and cultural issues that factor into the still-low numbers of women in engineering, computer science, and the physical sciences. Included here is our annual review of the social science literature on women in engineering and STEM, providing an extensive bibliography as well as analysis, insight, and recommendations. With nearly two decades of such reviews behind us, a spectrum of research questions, study results, and policy implications can be found in the compila-

tion of all our reviews to date, available at: <https://research.swe.org/literature-reviews/>.

This issue’s cover story, “Dismantling the Glass Ceiling,” brings fresh insights to the phenomenon of gender sidelining and re-examines the role of external recruitment and hiring practices as a key contributor to the glass ceiling. Similarly, the article “Fixing the Broken Rung in the Ladder to Success” looks at a 2019 report by McKinsey & Company that revealed the need to change hiring and promotion processes at the first-level management positions in order to approach gender parity.

Two of SWE’s latest research efforts are found in the articles “Women in Engineering Talent Pulse Report” and “The Community College Pathway: A Closer Look.” While the Talent Pulse Report examines how women engineers feel about their workplaces and what they seek in an employer, our community college research is a follow-up to a previous study SWE conducted on this pathway toward an engineering degree.

“The Role of Culture and Women’s Persistence in Engineering: A Bi-Continent Roundtable Discussion” documents the substance of dialogues among members of SWE’s predominantly U.S.-based research advisory committee and colleagues in Germany, Austria, and Romania. Held in Berlin during the Society’s WE Europe conference last May, the key takeaways are summarized in hopes of stimulating additional dialogues to inform best practices.

Lastly, “Increasing the Diversity of Patent Recipients” looks at efforts to broaden the participation of underrepresented groups in the patent process, and while such efforts offer promise, they have also pointed to larger problems in the patent system.

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Women in Engineering: A Review of the 2019 Literature

SWE's assessment of the most significant research found in the past year's social science literature on women engineers and women in STEM disciplines, plus recommendations for future analysis and study.

By Peter Meikins, Ph.D., Cleveland State University
Peggy Layne, P.E., F.SWE, Virginia Tech
Kacey Beddoes, Ph.D., San Jose State University
Jessica Deters, Virginia Tech

The past few years have, in some ways, been discouraging for advocates of gender diversity in engineering. The share of engineering jobs held by women has not increased significantly in the most recent period, and one continues to read headlines describing the ongoing controversies over the experiences of women in the digital economy. There has also been pushback against efforts to take positive steps to increase the numbers of women in engineering and science, with the federal government now joining efforts to eliminate scholarships and other supports that target female recipients.

Nevertheless, interest in understanding why there continue to be relatively few women in engineering and what can be done to change that remains strong. This year, for the annual SWE Literature Review, we read almost 200 peer-reviewed articles, plus books and papers from a variety of social science disciplines devoted to these issues. Our review summarizes the major findings published this year in the hope that practicing engineers will find them useful, both in understanding their own experiences and in helping to facilitate the entry of more women into the profession.

The research we reviewed varies in quality and in methodological approach: from quantitative analyses of large data sets to small, qualitative studies of a single workplace or a few individuals. As always, we have tried to focus attention on studies that are based on extensive research and the best scientific methods (both quantitative and qualitative), as well as those that offered new insights into established research questions or that pointed to important possible new directions for research.

Perhaps unsurprisingly, given that research on women in engineering has been ongoing for decades, our review of this year's literature revealed few significant new research directions. Although there was important new research published this year, most of it focused on familiar research questions, confirming or challenging findings from previous years and/or adding nuance to what is already known. Some of the more notable characteristics of this year's research include:

- A continued focus on the reasons girls and young women are not attracted to engineering. As evidence has accumulated that the low numbers of women in engineering are not the result of inequalities in aptitude or preparation in foundational skills such as math, researchers have focused increasingly on attitudinal and psychological variables: the "fit" between engineering and women's career goals and interests, women's self-concept and confidence in engineering-related skills, the effects of stereotype threat, sense of belonging, etc.
- A relative neglect of the reasons women leave engineering at various points along the career track, despite previous research establishing that the number of women in engineering careers is considerably lower than the number who earn engineering degrees. Researchers *are* conducting studies of factors such as the climate of engineering programs and workplaces and of work/life conflict, but we read very little research this year that explored how they led to women's departure from engineering (why did they leave, where did they go?), nor

did we read any research on women who had left engineering.

- Better balance between research on academic engineering and research on engineering practice. While there continues to be a significant amount of research devoted to engineering students and to female faculty, this year we found more research on engineering practice than we had in previous years.
- An international focus. For the past several years, we have noted the existence of a rich and growing literature on engineers outside the United States. This year was no exception, as we read many studies of engineers in a wide range of countries in both the developed and developing worlds. Some of this research is explicitly comparative, trying to understand how national culture affects the position of women in engineering. Some of it, however, is not, as we read studies conducted outside the United States, but published in American journals, that said little or nothing about how the national context in which the research was conducted was relevant to its findings. Of possible concern is the fact that the studies that paid least attention to national context were studies of engineers in North America, Europe, and Australia. One can ask whether researchers are at risk of treating the cultures of those countries as all the same and irrelevant to the experience of engineers. One can also ask whether they are unconsciously making the experience of the developed world the reference case, with comparative research effectively becoming a contrast between the developed and developing countries.
- A continued focus on intersectionality. Researchers continue to explore the interactions between sex, sexual orientation, race, and ethnicity and to build awareness that not all women engineers are the same.
- An ongoing focus on evaluating interventions. Researchers continue to be interested in discovering what can be done to increase the numbers of women in engineering and to improve their experience, in evaluating what works and what doesn't. As we will discuss in the concluding section of this review, the inter-

ventions being assessed differ in whether they are designed to “fix the women” or to change engineering in some fundamental way.

Finally, we were again struck this year by the fact that almost all of the research on women in engineering is conducted by women. There has been considerable interest within organizations such as the Society of Women Engineers in understanding the importance of male allies in efforts to diversify engineering. Perhaps that discussion should be extended to the research on which those efforts are based — does it matter that interest in understanding the underrepresentation of women in engineering seems to be concentrated largely among women themselves? We do note that we read several studies this year that explored masculinities in engineering, and/or that made a conscious effort to compare the experiences of men and women within the profession. It is possible that research of this type will broaden the group of researchers interested in exploring the lack of diversity in the engineering profession.

WHY AREN'T MORE GIRLS AND YOUNG WOMEN ATTRACTED TO ENGINEERING?

This year's literature review revealed ongoing interest among researchers in understanding why relatively few young girls and women are attracted to engineering programs and careers. One focus of interest continues to be in girls' experiences with math and in their spatial abilities, but there is a clear shift away from research on differences in aptitude or achievement to research on attitudes toward math, and on how others' perceptions of girls' abilities affect their interest in pursuing engineering or STEM careers.

Two studies we reviewed this year, however, *did* report differences in math achievement for girls and boys. Gomez Soler et al. (2019) reviewed national data on math achievement in Colombia, finding that boys outscored girls on standardized tests of math and that the gender gap *increased* after students entered university (they have no data to explain these findings). Marsh et al. (2019) reviewed longitudinal data on a national survey of Australian youth as well as outcomes on the Programme for International Student Assessment exam, finding that girls had lower math and

science test scores than boys (as well as higher reading scores).

Of course, these are studies from outside the U.S., and we know from American data that gender gaps on standardized tests of math don't predict success in math courses, where girls outperform boys, at least in the U.S. Perhaps more importantly, several studies we reviewed this year, including the Australian study by Marsh et al., find that attitudes, rather than math scores, were the key to determining whether girls gravitated toward STEM and engineering programs.

Marsh et al. (2019) found that, despite differences in math test scores, girls were equally likely to be in STEM courses in the last two years of high school (which in Australia is critical to being admitted to a postsecondary STEM program). However, girls were much less likely than boys to enroll in STEM courses in college, primarily because of psychological factors, including math anxiety, lower self-efficacy in math, as well as self-concept, interest,

and utility value in relation to math. Marsh et al. also interviewed a subsample of students who had taken STEM courses in their last two years of high school and found that those who opted out of STEM in college generally did so less because they were making a negative judgment of STEM, and more because they evaluated alternatives more highly.

Jungert et al. (2019) used data on almost 1,600 high school and junior college students in Sweden and Quebec, Canada, to examine the gender gap in STEM achievement and persistence. They found that a cognitive style known as "systematizing" indirectly predicted STEM achievement and persistence by way of intrinsic motivation, learning anxiety, and self-efficacy. Although boys and girls in their study had similar levels of academic achievement, boys were more likely to be classified as systematizing (and thus to be intrinsically motivated toward STEM and to have low learning anxiety in that area), which explained their greater persistence in STEM. Jungert et al. argue this

Backlash?

What is discrimination on the basis of sex? For years in STEM fields, discussion of sex discrimination has focused on the low numbers of women majoring in fields such as physics, engineering, and computer science. Organizations such as SWE have labored for decades to try to increase the numbers of women entering these male-dominated technical fields. As this literature review (which has been published for nearly two decades) reflects, researchers have struggled to identify the reasons for the continued underrepresentation of women in many STEM disciplines. Federal programs such as NSF ADVANCE, as well as a range of efforts initiated by professional associations, educational institutions, and others, have devoted significant resources to attempting to encourage more women to enter these fields and creating conditions under which they persist and are successful.

In a development reminiscent of the backlash against affirmative action programs in general, a counternarrative has emerged in arguing that *men*, not women, are the victims of sex discrimination in academic science and the tech sector more broadly. A 2015 suit against Yahoo, claiming the company discriminated

against male employees, and the circulation of a memo by a Google employee arguing that the low numbers of women in tech were *not* the result of discrimination, were early examples of this counternarrative. Publication of experimental research at Cornell concluding that women were actually *favored* in academic searches led to claims that there no longer is evidence of discrimination against women in academic hiring. Most recently, in a major shift of emphasis, the U.S. Department of Education (DOE) has initiated a series of investigations into universities that offer female-only scholarships, awards, development workshops, and engineering camps.

The DOE's move has been stimulated, in part, by the publication of a study by the nonprofit agency Stop Abusive and Violent Environments (SAVE), which found that most of the 220 universities studied offered single-gender scholarships targeting female students, often in STEM fields. SAVE labels these scholarship programs as "discriminatory" or, at best, "borderline." The organization, which describes itself as an advocate for gender equity on college campuses, also calls for greater equity in the handling of sexual harassment complaints. It argues, among other things, that sexual harassment grievance procedures risk becoming too

cognitive style can be taught, so the gender gap in STEM achievement and persistence is not the result of innate differences between boys and girls.

Seo, Shen, and Alfaro (2019) analyzed data from the 2002 Educational Longitudinal Study regarding adolescents' beliefs about math ability and their relationship to STEM career attainment. The data set allowed them to analyze a sample of more than 15,000 10th graders in 2002, with follow-up data both two and eight years after those students completed their secondary educations. They found that youths' belief in their math abilities predicted later STEM career outcomes, and that there were significant gender gaps in that belief among white and Latinx students, with girls having lower beliefs in their math abilities. There was no gender gap for black and Asian students, but black students did not reap the full benefits of their beliefs in their math abilities.

The study also found that a growth mindset about math — the belief that one can become

better at math — predicted high school math achievement, college STEM achievement, and eventual STEM career attainment for all groups. White adolescents had lower levels of growth mindset than the other groups studied; and, there was a significant gender gap among white adolescents, with girls significantly less likely to have a growth mindset. This study is an important demonstration both of the role of psychological variables in shaping young people's choice of major and career *and* of the importance of attending to intersectionality.

Zawistowska and Sadowski (2019) analyzed the gender gap in pursuing a high-stakes math exam in Poland, using national data from the 2016 exam. The results on this exam are the main criterion for admission to education for the majority of technical occupations in Poland. Women are significantly less likely to take the exam (and thus are less likely to pursue technical careers), but this was not the result of skill differences. Zawistowska and

“victim centered” and that the ways in which, under Title IX, complaints of harassment are being handled are not effective in defending the rights of the accused.

Universities have already begun to respond to the DOE's scrutiny. At the University of Minnesota, Mark Perry, Ph.D., an alumnus now teaching at the University of Michigan-Flint, filed complaints about three female-only faculty research awards. In response, the DOE launched an investigation into possible Title IX violations against men in August 2019; the university is now considering how to respond. It had already modified several women-only awards and scholarships a year earlier in response to complaints filed by Dr. Perry. Clemson University has also had to respond. Again, in response to complaints by Dr. Perry, Clemson came under investigation by the DOE for possible Title IX violations against men. The investigation was closed when the university agreed to open a series of female-only pre-college STEM programs to male students.

Efforts to increase the numbers of women in disciplines such as engineering, physics, and math continue across the United States. And, despite progress in some areas (e.g., improved outcomes for women in math) women continue to be significantly underrepresented

in these fields at all levels, from undergraduate students to academics and practitioners. Thus, more needs to be done if sexual equality in STEM is to be achieved. However, continued efforts to take positive steps to increase the numbers of women in fields such as engineering may be in jeopardy if the counternarrative claiming there is discrimination against men continues to take root.

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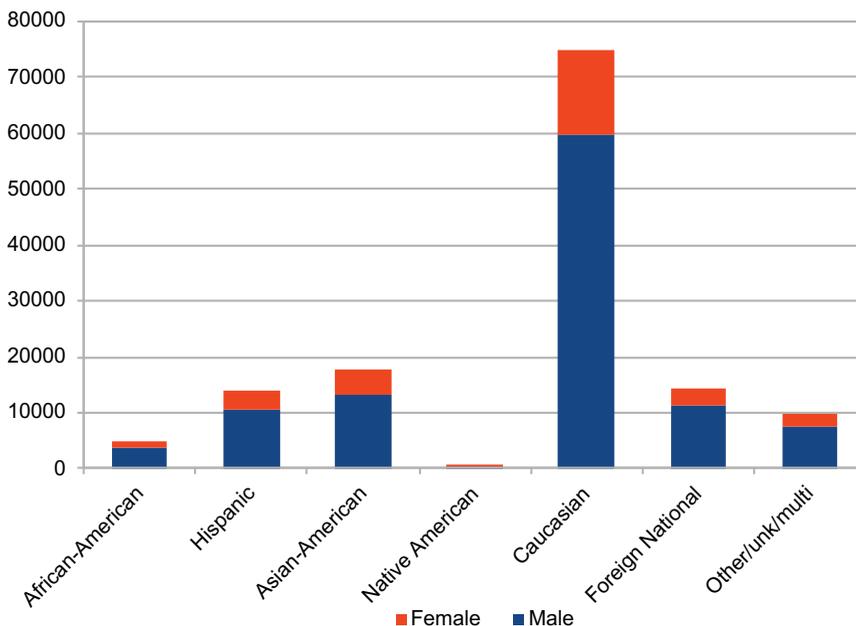
Sadowski found that girls are less likely to take the exam when compared with boys with similar math scores and/or who attended similar schools. They conclude that the Polish technical educational system is at greater risk of losing math-talented girls than math-talented boys, in part because high verbal skills are more likely to draw women away from pursuing math-based educational programs.

Other researchers focused attention on how students' choices are affected by the judgments of others. For example, Muenks et al. (2019) surveyed 117 high school students and their parents in the mid-Atlantic region to examine how parents' beliefs about their children's spatial abilities affect students' STEM career intentions. They found that the parents of boys believed their children had higher spatial abilities, even after controlling for actual spatial abilities. Parents who believed their children had higher "mental manipulation abilities" were more likely to encourage their children to pursue STEM careers, and their children were more likely to have STEM career intentions. Beliefs about spatial visualization and navigation abilities did not have a similar effect; the researchers specu-

late that parents may not believe these abilities are important to success in a STEM career.

Studies that present at least indirect evidence of the influence of others on young women's attitudes to engineering include Hodgkinson, Khan, and Braide's (2019) small-scale study of a dozen undergraduate engineering and navigation students in the United Kingdom, which found that their respondents had been drawn to their programs of study because they were good at math and science, but that many of them reported not having been presented with engineering as an option in school; and that family members had often been important influences on their decisions to pursue those programs of study. Dicke, Safavian, and Eccles (2019) analyzed data on 744 participants in the Michigan Study of Adolescent and Adult Life Transitions, which followed participants over a 30-year period from age 11 to age 42, and found that women who had been brought up to have "traditional" attitudes about work/family-related gender roles (e.g., the belief that the man should be the achiever outside the home and the woman should take care of home and

Engineering Bachelor's Degrees by Gender within Race/Ethnicity, 2018



Source: Roy, Engineering by the Numbers, American Society for Engineering Education, 2019

family) had lower levels of educational attainment and a significantly lower probability of being in STEM-related careers, particularly in the physical sciences and engineering.

Previous research has explored the idea that women self-select away from or are steered away from fields in which people believe that “brilliance” is a required characteristic. Disciplines such as physics are culturally linked to brilliance, and brilliance tends to be defined as male, so girls are unlikely to enter. Galvez, Tiffenberg, and Altszyler (2019) demonstrate that the stereotype of male brilliance remains prevalent in contemporary culture. They analyzed transcripts of more than 11,000 English-language films made between 1967 and 2016. Using “natural language processing techniques” to look for associations between gender pronouns and high-level cognitive ability-related words (genius, clever, intelligent), they found that the stereotypical association between genius and masculinity persisted throughout the period they studied, and that it was also present in the subset of children’s films they examined.

Deiglmayr, Stern, and Schubert (2019) conducted research in Switzerland designed to explore the connection between beliefs in brilliance and women’s feelings about belonging in STEM. They surveyed almost 1,300 STEM students (18% of whom were female) at a technical university, finding that respondents associated brilliance with more math-intensive fields (physics, math) and that women reported higher levels of belief in brilliance than men. A small, but significant portion of the gender difference in uncertainty about belonging in STEM was explained by the belief in brilliance. However, the same study also reported that female enrollment in math and physics was higher than in engineering, a field that respondents did not associate with brilliance. So, it may be that beliefs in brilliance do not explain the underrepresentation of women in engineering after all.

The question of whether girls have different substantive and career interests than boys and, if they do, whether this affects their interest in pursuing engineering careers, continues to be examined by researchers. Some of the research we reviewed this year, however, cast doubt on whether this is the key factor limiting the numbers of women in the field.

Several studies did offer support for the view that women have different interests and orientations that may affect their choice of career. Lakin, Davis, and Davis (2019) surveyed 996 undergraduates enrolled in a pre-engineering course at a large public research-oriented university in the United States, finding that female students showed greater value for altruism while men showed greater value for status. Ertl and Hartmann (2019) conducted a quantitative analysis of data on almost 13,000 first-year students in Germany; they found that STEM fields with low proportions of female students tended to be more “things-oriented,” while those with higher proportions of female students were more “people-oriented.” Swartz et al.’s (2019) survey of just over 500 students enrolled in five engineering classes at the Colorado School of Mines and the University of Colorado Boulder concluded that female students have a greater understanding of and appreciation for the value of nontechnical knowledge, suggesting that female students more readily understand the importance of drawing from a diverse pool of stakeholder perspectives when they begin careers as engineers. And Barco et al.’s (2019) pilot study of a small group of female high school robotics students in New Zealand found that the students’ motivation to study robotics was higher when social applications were used in the class.

Studies such as these, which confirm earlier research exploring the different interests of young men and women, point to the conclusion that these different interests explain gendered career choices. But is that, in fact, true? Lakin, Davis, and Davis (2019) question this in several ways. Although they found evidence of women’s greater interest in altruism, they argue that the differences were significantly smaller than were found in other studies. More importantly, they note that the commitment to remain in engineering was lower for respondents who valued status most highly and who perceived engineering as providing it. This finding raises questions about the degree to which career commitment and career values are closely linked.

Ertl and Hartmann’s (2019) research raises similar questions. Although they report that women were concentrated in the more people-oriented

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2019 Outstanding Women in Engineering

American Indian Science and Engineering Society (AISES) Awards

PROFESSIONAL OF THE YEAR AWARD

Wendy F. Smythe, Ph.D., University of Minnesota Duluth

TECHNICAL EXCELLENCE AWARD

Otakuye Conroy-Ben, Ph.D., Arizona State University

BLAZING FLAME AWARD

Sheila Lopez, Intel

American Society for Engineering Education (ASEE) Awards

WILLIAM ELGIN WICKENDEN AWARD

Chandra Turpen, Ph.D., University of Maryland, College Park

CLEMENT J. FREUND AWARD

Patricia D. Bazrod, retired, Georgia Institute of Technology

SHARON KEILLOR AWARD

Jenna P. Carpenter, Ph.D., Campbell University

AnitaB.org ABIE Awards

TECHNICAL LEADERSHIP ABIE AWARD

Fei-Fei Li, Ph.D., Stanford University

STUDENT OF VISION ABIE AWARD

Jhillika Kumar, Georgia Tech

EMERGING TECHNOLOGIST ABIE AWARD

Natalya Bailey, Ph.D., Accion Systems

SOCIAL IMPACT ABIE AWARD

Nimmi Ramanujam, Ph.D., Duke University

EDUCATIONAL INNOVATION ABIE AWARD IN HONOR OF A. RICHARD NEWTON

Yamilée Toussaint Beach, STEM From Dance

National Academy of Engineering (NAE) Awards

NEW FEMALE MEMBERS

Joanna Aizenberg, Ph.D., Harvard University

Penina Axelrad, Ph.D., University of Colorado Boulder

Mary Baker, Ph.D., P.E., ATA Engineering Inc.

Gilda A. Barabino, Ph.D., The City College of New York

Ana P. Barros, Ph.D., Duke University

Linda J. Broadbelt, Ph.D., Northwestern University

Wei Chen, Ph.D., Northwestern University

Hariklia Deligianni, Ph.D., retired, IBM Corp.

Sharon C. Glotzer, Ph.D., University of Michigan, Ann Arbor

Dorota A. Grejner-Brzezinska, Ph.D., The Ohio State University

Linda P. Hudson, The Cardea Group

Sara Kiesler, Ph.D., National Science Foundation

Jessica E. Kogel, Ph.D., National Institute for Occupational Safety and Health

Monica S. Lam, Ph.D., Stanford University

Kathryn A. McCarthy, Ph.D., Canadian Nuclear Laboratories

Laura J. McGill, Raytheon Missile Systems

Mahta Moghaddam, Ph.D., University of Southern California, Los Angeles

Mary Pat Moyer, Ph.D., INCELL Corp. LLC

Sharon L. Nunes, Ph.D., IBM Corp.

Stephanie L. O'Sullivan, U.S. Office of the Director of National Intelligence

Rosalind Picard, Sc.D., Massachusetts Institute of Technology

Kimberly A. Prather, Ph.D., University of California, San Diego

Nadine B. Sarter, Ph.D., University of Michigan, Ann Arbor

Margo I. Seltzer, Ph.D., Harvard University

Heidi Shyu, Heidi Shyu Inc.

Wanda A. Sigur, Lockheed Martin Corp.

Jane McKee Smith, Ph.D., U.S. Army Corps of Engineers

Kay M. Stanney, Ph.D., Design Interactive Inc.

Jean W. Tom, Ph.D., Bristol-Myers Squibb

Claire J. Tomlin, Ph.D., University of California, Berkeley

Susan Trolier-McKinstry, Ph.D., The Pennsylvania State University

Christine A. Wang, Ph.D., MIT Lincoln Laboratory

Margaret M. Wu, Ph.D., ExxonMobil Research and Engineering Co.

New International Members

Kiran Mazumdar-Shaw, Biocon Limited, Bangalore, India

Nicola A. Spaldin, Ph.D., ETH Zürich, Zürich

Molly Stevens, Ph.D., Imperial College London, U.K.

National Society of Black Engineers (NSBE) Golden Torch Awards

OUTSTANDING WOMAN IN TECHNOLOGY

Cynthia Pierre, Ph.D., BP Cherry Point Refinery

ENTREPRENEUR OF THE YEAR

Tarolyn Buckles, Onyx Enterprise Inc.

PROFESSIONAL MEMBER OF THE YEAR

Luneta Louis, John Deere

Society of Hispanic Professional Engineers (SHPE) Awards

JAIME OAXACA AWARD

Diana Ortega, General Motors Company

DR. ELLEN OCHOA AWARD

Ellen Ochoa, Ph.D., NASA

RUBÉN HINOJOSA STEM AWARD

Sylvia Acevedo, Girl Scouts USA

ADVISOR OF THE YEAR

Carrie Robinson, Ed.D., Arizona State University

EDUCATOR OF THE YEAR—HIGHER EDUCATION

Monica Palomo, Ph.D., California State Polytechnic University, Pomona

MANAGER OF THE YEAR AWARD

Karen Siles, IBM Corporation

PROFESSIONAL ROLE MODEL

Laura Valencia Fritsch, Eaton

Yamille Perez, Caterpillar

STUDENT ROLE MODEL

Lucila Campos, Utah State University

Susana Campos, The University of Texas Rio Grande Valley

Daisy Cueto, University of Illinois at Chicago

Giannina Duran, Florida Atlantic University

Alina Garcia Taormina, Ph.D., University of Southern California

Society of Women Engineers (SWE) Awards

SUZANNE JENNICHES UPWARD MOBILITY AWARD

Endowed by Northrop Grumman Corporation

Carol Malnati, Medtronic

RESNIK CHALLENGER MEDAL

Meg Abraham, DPhil, The Aerospace Corp.

WORK/LIFE INTEGRATION AWARD

Roble Alanis, John Deere

ADVOCATING WOMEN IN ENGINEERING AWARD

Blythe Gore Clark, Ph.D., Sandia National Laboratories

Katherine J. Herrick, Ph.D., Raytheon Company

Jennifer Howland, IBM Corporation

Marilyn Tears, ExxonMobil

Marilee J. Wheaton, F.SWE, The Aerospace Corporation

GLOBAL LEADERSHIP AWARD

Tamara Hedgren, Deere & Company

Tami Heilman-Adam, Dow

Elisabeth C. Martin, The Boeing Company

GLOBAL TEAM LEADERSHIP AWARD

Liza Phase 1 Project Team, ExxonMobil

Global Team – Standardized RFID System for Medical Device Implant Tracking, Johnson & Johnson Supply Chain

Islands Energy Program, Rocky Mountain Institute

PRISM AWARD

Karen Devine, Ph.D., Sandia National Laboratories

Lynda Grindstaff, F.SWE, McAfee

Kayleen L.E. Helms, Ph.D., Intel

Colleen O'Shea McClure, The Boeing Company

Susan B. Orr, Medtronic

SPARK AWARD

Stacy Kalisz Johnson, Keysight Technologies

Reiko A. Kerr, Los Angeles Department of Water and Power

Leslie L. Oliver, Solar Turbines – A Caterpillar Company

Karen Tokashiki, Northrop Grumman

Mary C. Verstraete, Ph.D., F.SWE, The University of Akron, Retired

EMERGING LEADER

Elif Ertekin, Ph.D., University of Illinois at Urbana-Champaign

Britta Jost, Caterpillar Inc.

Jamie Krakover, The Boeing Company

Jennifer LaVine, Sikorsky Aircraft – A Lockheed Martin Company

Jessica Mattis-Carolan, General Motors

Kate Maxwell, Raytheon Company

Alexis McKittrick, Ph.D., IDA Science & Technology Policy Institute

Heather A. Spinney, Ph.D., Dow Inc.

Orietta Verdugo, Intel Corporation

Kristen White, Keysight Technologies

SWE DISTINGUISHED NEW ENGINEER

Alya Elhawary, Lockheed Martin

Katharine Brumbaugh Gamble, Ph.D., U.S. Government

Anne Maher, Medtronic

Kimberly Miller, Cereal Partners Worldwide

Sarvenaz Myslicki, American Express
Sowmya Nagesh, Caterpillar Inc.

Elaine Reeves, Microsoft Corporation

Megan B. Schulze, P.E., Dewberry

FELLOW GRADE

Cindy L. Dahl, P.E., ONAMI Inc.

Jonna Gerken, Pratt & Whitney, a United Technologies Company

Rachel A.B. McQuillen, P.E., CME Associates Inc.

Michele O'Shaughnessy, U.S. Department of Energy, Savannah River Site

Deborah Stromberg, Intel Corporation

Frances Stuart, Retired

Carol J. Weber, Caterpillar Inc.

DISTINGUISHED SERVICE AWARD

Mary Higgins Studlick, P.E., F.SWE, ExxonMobil, Retired

OUTSTANDING FACULTY ADVISOR

Helene Finger, P.E., Cal Poly, San Luis Obispo

OUTSTANDING SWE COUNSELOR

Maira Garcia, Honeywell Aerospace

OUTSTANDING COLLEGIATE MEMBER

Haley Antoine, Cornell University

Megan E. Beck, Northwestern University

Carolyn Chlebek, Cornell University

Shelby Ann Freese, California State University, Chico

Cecilia Klauber, Texas A&M University

Kathryn Lockhart, Bradley University

Shwetha Rajaram, University of Michigan

Meredith Lucy Richardson, University of Illinois at Urbana-Champaign

Mujan Seif, University of Kentucky

Stephanie Tu, Rutgers University

Women in Engineering ProActive Network (WEPAN) Awards

WEPAN/DISCOVERE INTRODUCE A GIRL TO ENGINEERING DAY AWARD

University of Illinois at Chicago, Introduce a Girl to Engineering Day

INCLUSIVE CULTURE AND EQUITY AWARD

Susan E. Walden, Ph.D., The University of Oklahoma

WIE INITIATIVE AWARDS

California State Polytechnic University, Pomona, Women in Engineering Program

The Pennsylvania State University, Engineering Mentoring for Internship Excellence

INDUSTRY TRAILBLAZER AWARDS

Aicha Evans, Zoox

Cynthia Murphy-Ortega, Chevron

BETTY VETTER RESEARCH AWARD

Joyce B. Main, Ph.D., Purdue University

FOUNDERS AWARD

Julie Martin, Ph.D., Clemson University

WEPAN PRESIDENT'S AWARD

Lesia Crumpton-Young, Ph.D., Tennessee State University

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STEM fields, they found that the congruence between individual interest profiles and vocational aspirations was generally low in all STEM fields, and particularly small in those with low proportions of women. In other words, many of the students they studied were choosing to pursue careers in STEM fields that did not align with their stated interests.

Bielefeldt and Canney (2019) surveyed 450 engineering graduates from 16 U.S. institutions to explore whether engineers were satisfied with their ability to help people and society in their jobs. The study needs to be considered with caution, since the sample appears skewed toward younger engineers and those who had engaged in service activities. The response rate to the survey was also relatively low (14%), and the sample overrepresents women (40%). Nevertheless, the study found no significant gender differences in levels of satisfaction with opportunities to help others.

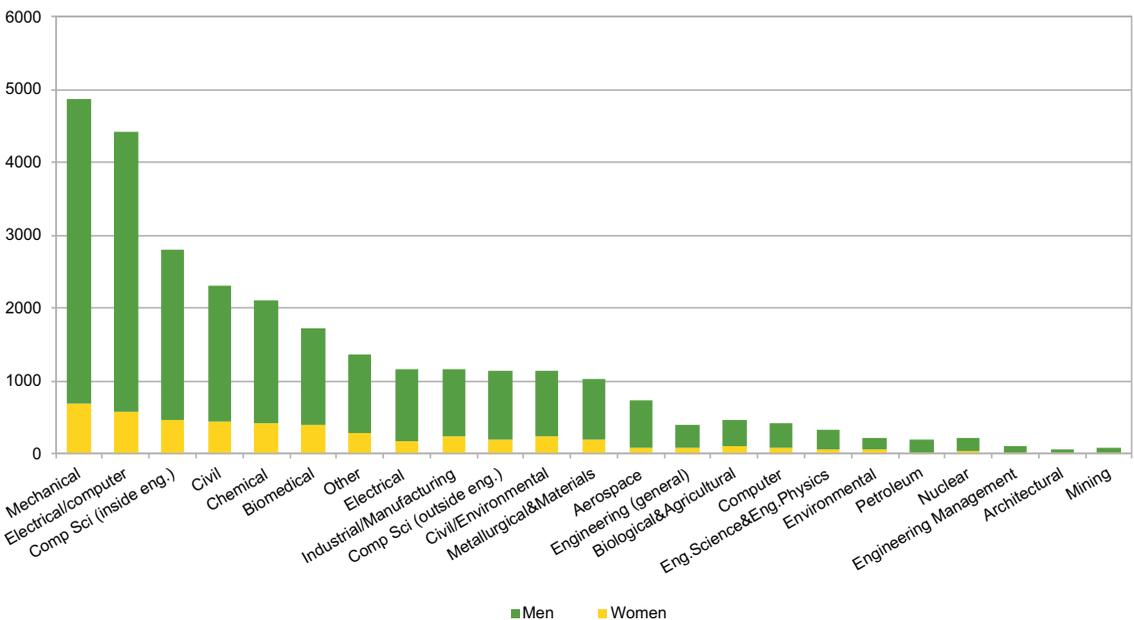
Just as people’s choice of career may not be directly related to their interests (whether these are gendered or not), it is also possible that people’s sense of the fit between themselves and their careers is malleable. Dunlap and Barth (2019) note this

possibility in their study of the relationship between people’s perceptions of the “fit” between themselves and the fields in which they work. They interviewed 117 heterosexual couples, 55 of which included a woman majoring in a STEM field. They found that both men and women in STEM fields tended to see strong associations between their chosen fields and their own genders — in the case of women, this obviously involved counter-stereotypical associations. Significantly, however, Dunlap and Barth do not attribute causality to their findings:

“Whether women majoring in STEM choose to do so because of their counter-stereotypical association or whether those associations develop as a result of their career choice remains to be seen.” (557)

This year’s research on the factors shaping young women’s decisions about whether to enter engineering and STEM focuses attention clearly on the role of psychological and attitudinal factors: Are young women confident in their math abilities? Do they feel that they “belong” in engineering? Do they believe they can pursue their interests with a career in the field? It is important to emphasize, however, that this is *not* the same thing as saying that women

Engineering Faculty by Discipline and Gender, 2018



Source: Roy, Engineering by the Numbers, American Society for Engineering Education, 2019

have a negative view of engineering and engineering careers. On the contrary, there is a growing sense in the literature that women choose not to enter engineering and other STEM fields not because they have a strongly negative view of STEM, but because they find other fields more appealing.

Reskin and Roos (1990), in their classic analysis of the dynamics of occupational gender segregation, showed that as more women entered the labor force in the latter part of the 20th century, they tended to enter occupations in which they were interested and that were open to them. They might have had an interest in other occupations, but there were sufficient men to fill them, so women made other occupational choices. Pearlman's (2019) analysis of declining gender segregation in the 21st-century labor force implies that something similar may be occurring in the case of engineering. She argues that the declining probability that college-educated women will be in gender-segregated occupations (such as engineering) is related not to changes in the gender composition of historically male-dominated (or female-dominated) occupations, but to the growth in employment in more gender-integrated occupations such as management. It may be, in other words, that college-educated, math-talented women are choosing to enter management and other gender-integrated careers, rather than trying to make their way into historically male-dominated professions such as engineering. Women may not have an entirely negative view of the field, but entering engineering involves overcoming gender stereotypes and barriers; plus, they have options. So, one must ask whether increasing the numbers of women in engineering is simply a matter of addressing psychological and attitudinal factors among women themselves — e.g., increasing women's math confidence or sense of belonging in engineering. Doing so may also involve eliminating the barriers that women who are already attracted to engineering may be encountering.

THE STUDENT EXPERIENCE

What happens to young women who develop an interest in engineering and enter an engineering program in university? Research reviewed in previous years finds that women do not leave en-

gineering programs at higher rates than men. But, there remains concern that engineering programs are not as welcoming to women as they could be and that this is part of the reason some female graduates don't continue to engineering careers.

The literature we reviewed this year offers contrasting views on whether the experience of being a female student in an engineering program is a positive one. Salehi, Holmes, and Wieman (2019) analyzed responses from students in two introductory mechanical engineering courses at Stanford University to determine whether gender affected students' perceptions of their peers, something that had been found to be the case in previous research on biology classes. They found no evidence of gender bias; students "nominated" as good students both male and female peers, typically other students they knew and who had good grades.

Similarly, Denis and Heap (2019) analyzed 2004-2008 data from faculty and students at three central Canadian universities with higher than average female undergraduate enrollment in engineering. They reviewed various aspects of the student experience at these universities, finding very few gender differences in descriptions of what the student experience was like, although female students at the "large" university in the study were more likely than the male students to say that the climate there favored male students.

On a more negative note, Tao and Gloria's (2019) study of 224 female STEM doctoral students at a Midwestern university found that some of them suffered from "imposterism" — a feeling of not being good enough, of being exposed as lucky or as a fraud — and that this led to lower self-efficacy and a negative view of their field. These feelings were not specific to engineering — students in all the STEM fields studied experienced them. However, Tao and Gloria do not indicate that women are more likely than men to experience these feelings, nor do they indicate how common they are among their respondents. And, they note that other factors reduced the feeling of imposterism for some respondents — e.g., having ample opportunities to engage in meaningful research with like-minded others.

Casad, Petzel, and Ingalls (2019) surveyed 579 female STEM undergraduates at two U.S. public

universities to examine whether they experience a threatening environment and, if so, how that affects them. They found that women in STEM experienced a negative campus climate and that this predicted lower academic engagement and self-esteem. Women in male-dominated majors such as engineering reported a more negative campus climate, and women who were members of racial minorities reported greater stigma consciousness, as well as more math and science disengagement, than white women did.

Leaper and Starr (2019) surveyed a group of undergraduate women to assess their experience of gender bias and sexual harassment. Most of their respondents reported experiencing bias or harassment in the past year and that these experiences were associated with reduced STEM motivation and career aspirations. Support from others, particularly friends, partially counteracted these negative effects. Leaper and Starr's sample consists of biology majors, so these results cannot be assumed to apply to engineering programs (particularly in light of Salehi, Holmes, and Wieman's research, discussed above). Nevertheless, the study documents the reality that some STEM students experience bias and harassment and points to the need for more research on engineering students to determine if Salehi, Holmes, and Wieman's findings pertain beyond Stanford.

Jensen and Deemer (2019) studied 363 female undergraduate STEM students at a Midwestern land-grant university. Their sample excluded students in the biological sciences. They found, unsurprisingly, that experience of a chilly climate led to higher levels of emotional exhaustion and cynicism and that this was related to higher levels of academic burnout. Chilly climate did not lower women's academic efficacy; the authors speculate that a hostile environment may motivate women to complete their goals.

Whether female engineering students' experiences are positive or negative, several studies we reviewed this year consider practices that might help to make their experiences better. Jackson et al.'s (2019) survey of almost 400 first-year STEM students at a public university in California found that female students with a low to average science identity showed greater science interest over time

if they felt that others understood and encouraged their interest in science. Fisher et al. (2019) surveyed almost 500 graduate students in STEM programs in California (biological sciences were not included). Most of the students surveyed were women or members of underrepresented minority groups or, in some cases, both. The female students in the survey reported higher distress rates than their male peers, but the researchers found that feeling prepared for graduate classes, feeling accepted, and receiving clear expectations were positively associated with student publication rates and with subjective well-being. These findings should be treated with caution, however, as the sample is confusingly described and the researchers don't appear to have analyzed differences between women of different racial backgrounds, or between black and Latinx students. Nevertheless, the research suggests that relatively simple steps (such as making expectations clear) can significantly improve female students' experience.

Wylie (2019) reports on a very interesting ethnographic study of an engineering research lab at a medium-sized U.S. public university between 2016 and 2018. She describes this lab as unusual because part of the learning process in it involved hearing about "disaster" stories in which the lab director and her student assistants told stories about failures. Wylie argues that these stories differed from the usual "war stories" of competition and were characterized by self-deprecation and the encouragement of mutual trust and inclusion. She speculates that there may be a lesson here for those interested in the experiences of women in engineering:

"It is possible that this self-deprecating, inclusive discourse style common in Kate's lab originates with how Kate's identity and reception as a woman shape her worldview, including how she thinks about her research group. Kate's experience as a woman engineer may also explain why her lab has more women students than most engineering communities." (834)

Syed et al.'s (2019) study of 502 current or recently graduated undergraduate STEM students found that research experience, instrumental mentoring, and involvement in a community of scientists were positively linked to engineering/science self-efficacy

and identity, which in turn was linked to commitment to a STEM career. These relationships existed for both male and female students. Unfortunately, the researchers do not report on the likelihood that female students will have these experiences, pointing to a direction for additional research.

Jarboe et al. (2019) compared the characteristics of chemical engineering departments (a relatively high gender diversity engineering discipline) to electrical engineering (in which gender diversity is low). They examined Integrated Postsecondary Education Data System (IPEDS) data on more than 80,000 graduates of 95 universities for the period from 2010-2016. Surprisingly, the authors found no relationship between the gender diversity of faculty and the diversity of degree recipients, a finding at odds with some previous research. Gender diversity among EE graduates was significantly decreased when a separate degree in computer engineering was available. In contrast, there was no significant impact on gender diversity of ChE graduates when a biology-associated degree was available. Perhaps the most important finding in this study is that

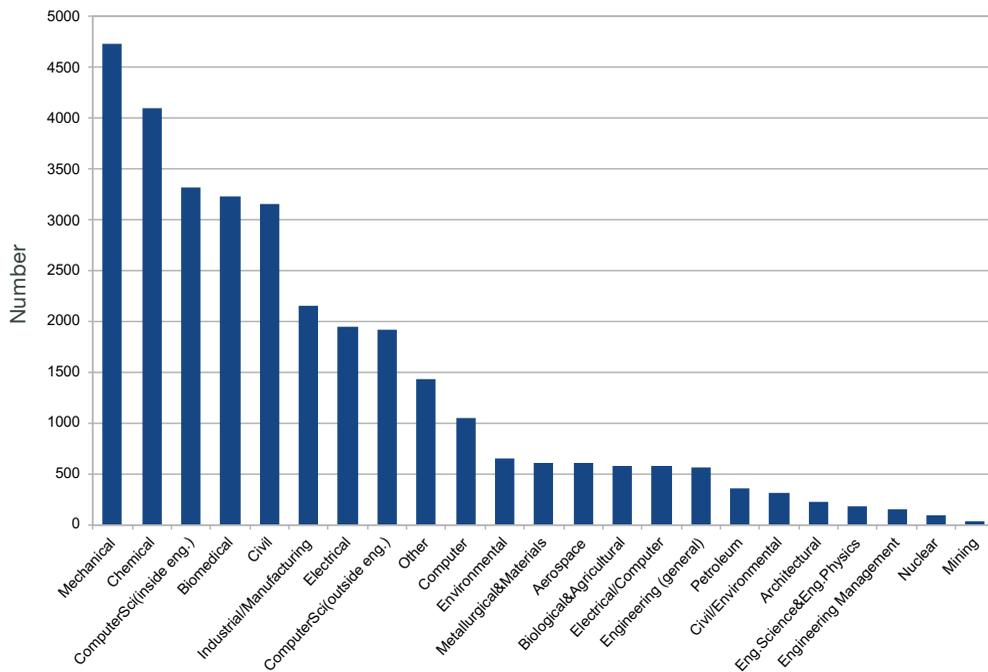
state variations in funding of K-12 education at the level of instructional staff support significantly impacted the gender diversity of graduates in both fields. Perhaps increasing the numbers of women enrolling in university engineering programs depends, in part, on increasing the availability of resources to primary and secondary schools!

Gelles, Villanueva, and Di Stefano (2019) conducted a small, exploratory study of faculty and graduate students at a Western public university. Their findings emphasize the potential positive value of “ethical” mentoring, rooted in six guiding principles: beneficence, nonmaleficence, autonomy, fidelity, fairness, and privacy. The authors also note the importance of being aware of the power imbalance in mentoring relationships and that mentors need to be aware of the unique characteristics of the students with whom they work.

Finally, Haynes (2019) describes a set of interviews she conducted with a small group of students who participated in an engineering living-learning

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Number of BS Engineering Degrees to Women by Discipline, 2018



Source: Roy, Engineering by the Numbers, American Society for Engineering Education, 2019

Women and the Tech Economy

A significant reason for the continued underrepresentation of women in STEM in general, and engineering in particular, is the reality that there are so few women in the sectors that have been growing fastest — computer science, computer engineering, information science; i.e., the sectors that make up the digital economy.

As social scientists and journalists have turned their attention to understanding why, we are beginning to learn a great deal about how the digital economy got to be so male dominated. It wasn't always that way, as the first "computers" were largely women; but as the work became more prestigious and better paid, and as the search for new employees came to focus on people who fit the emergent stereotype of the nerdy but brilliant male, women were gradually displaced. We have also learned much about the male culture of high tech, as books such as Emily Chang's *Brotopia* (discussed in last year's review) reveal the ways in which sexual harassment and toxic masculinity combine to make it an uncomfortable place for women to work. Two new books published this year offer additional insights into the culture of digital industry. Neither is intended specifically to be a book about gender and the tech sector. But, each points to an aspect of the sector's culture and mode of operation that helps to explain why few women find their way into it and why some of those who do eventually leave.

The Code: Silicon Valley and the Remaking of America, by Margaret O'Mara, Ph.D., tells the story of the rise of the Silicon Valley, from its origins in the aftermath of World War II to its current dominant position in the global digital economy. Her primary concern in the book is to dispel the myth that the rise of the Silicon Valley was purely the result of entrepreneurial independence. While she acknowledges that this was indeed a crucial element in the Valley's success, she emphasizes that government played a central role, from creating a legal context in which entrepreneurship and venture capital could flourish to directly funding many of the ideas that eventually became today's tech behemoths.

In detailing the history of the various enterprises that arose within the Silicon Valley, Dr. O'Mara makes clear that this is largely a history of men. She does make a point of focusing on a few women who played important roles in the Valley's development, but, in doing so,

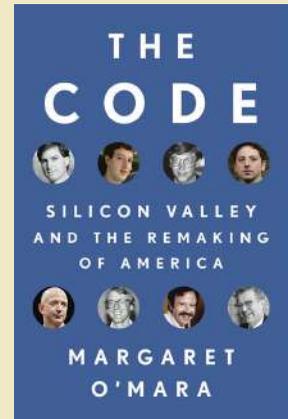
she reveals that some of the most important women were in non-technical positions. For example, she emphasizes the important role played by Mary Meeker, a Morgan Stanley stock analyst whose knack for picking the right internet companies in which to invest led to her being called the "Queen of the

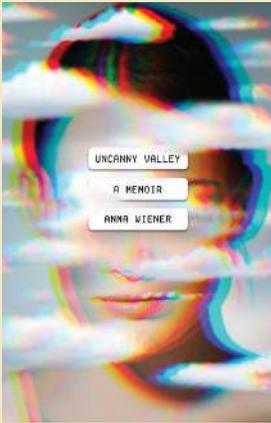
Net." The few women she describes who fulfilled important technical roles encountered discrimination and a hostile male culture in their work. For example, she follows the career of Ann Hardy, who began at IBM, then moved to Tymshare, where she played a central part in developing technology that allowed multiple simultaneous users on a single computer, but where she was not given the stock options given to men. When Tymshare was acquired by McDonnell Douglas in 1984, she became the company's only female vice-president, but was quickly pushed out, eventually founding her own company, which subsequently failed in the dot-com bust of 2001.

One of the reasons Dr. O'Mara identifies for the success of the Silicon Valley also helps to explain why women have been largely on the margins. She emphasizes that a key element in the tech industry's ability to grow large and powerful was the maintenance of tightly coiled networks of influence and investment:

"The Valley power players knew the tech, knew the people, and knew the formula that worked. They looked for "grade A men" (who very occasionally were women) from the nation's best engineering and computer science programs, or from the most-promising young companies, and who had validation from someone else they already knew... Keeping the networks tight and personal was a critical part of Silicon Valley's ability to keep the flywheel turning, to move from chips to micros to dot-com to the next Web without dropping the pace." (pp 399–400)

While she holds out hope that a new generation of tech workers is emerging that may reject the tra-





ditional culture of the Silicon Valley, Dr. O'Mara also notes that women who have been active in efforts to foster change are skeptical that the tight networks that have fostered that culture are likely to break down in the foreseeable future.

Anna Wiener's *Uncanny Valley: A Memoir* provides a different insight

into the male domination of tech. Wiener, a liberal arts graduate, became frustrated with her young career working in publishing in New York, so moved to Northern California to work for a data analytics firm. One of the few women employed by the company, she worked there for a year or so, but grew fed up with the pressure to work long hours, the "boys club" atmosphere, and the highly personalized managerial style, which made it difficult to know how one was doing or how to get ahead. Eventually, she left the company for an open-source start-up, which promised, and to an extent provided, a more relaxed work atmosphere.

Wiener notes that since she worked largely in customer support, she was "around tech" rather than in it. Nevertheless, she describes work environments in which women are not treated equally (e.g., are offered less or no opportunity to acquire equity in start-ups) and suffer from exposure to a kind of casual, toxic masculinity and incidents of more explicit harassment. While attending a conference on women in computers, she discovers that, if anything, women in technical roles suffered more from these problems than she did:

"Everyone I knew in tech had a story, first- or secondhand. That week, I heard new ones: the woman who had been offered an engineering job, only to see the offer revoked when she tried to negotiate a higher salary; the woman who had been told, to her face, that she was not a culture fit. The woman demoted after maternity leave. The woman who had been raped by a "10X" engineer, then pushed out of the company after reporting to HR. The woman who had been slipped GHB by a friend of

her CEO. We had all been told, at some point or another, that diversity initiatives were discriminatory against white men; that there were more men in engineering because men were innately more talented." (p. 178)

This aspect of Wiener's account will sound familiar to readers of other books about the male character of tech. Her description of the work itself, however, adds something new to our understanding of why the sector is so homogeneous. She argues that despite its self-presentation as disruptive and potentially revolutionary, and despite its counter-cultural veneer (casual dress, casual sex, drug use, communalism, etc.), the work in which she was involved was unsatisfying and not really radical at all:

"It seemed to me that whatever I had, that the men of Silicon Valley did not, was exactly what I had been trying to sublimate for the past four years. Working in tech had provided an escape from the side of my personality that was emotional, impractical, ambivalent and inconvenient – the part of me that wanted to know everyone's feelings, that wanted to be moved, and that had no apparent market value... The novelty was burning off; the industry's pervasive idealism was increasingly dubious. Tech for the most part wasn't progress. It was just business." (p. 260)

Wiener acknowledges there are people (most of the ones she met were men) for whom this was enough. They enjoyed building systems; were drawn to power, wealth, and control; and "saw markets in everything" (p. 262). But this work tends to select for a particular kind of person, to produce a homogeneous culture and workforce. Combined with the sexism that thrived in that environment, this may help to explain why it is difficult to stimulate diversity in the tech sector.

Sources:

O'Mara, Margaret. 2019. *The Code: Silicon Valley and the Remaking of America*. New York: Penguin Press.

Wiener, Anna. 2020. *Uncanny Valley: A Memoir*. NY: Farrar, Strauss and Giroux.

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community at a U.S. university. This is a small, exploratory study, but it adopts the interesting approach of trying to learn about the positive metaphors female engineering students used to describe their experiences. She reports how the students describe one another as a support system, how they found the living-learning program to be both a starting point and a neighborhood, and how they tried to emphasize that being different is “normal.” These findings point to the conclusion that creating a welcoming environment for female engineering students is helped by having female peers, by feeling a sense of community, and by the acceptance of difference.

CAREERS

In last year’s review, we discussed several studies that explored the transition from engineering school to work, a transition during which some female engineering graduates leave engineering altogether. We did not read any studies of this transition this year, but we did find several studies of engineering workplaces, both academic and within the larger economy.

ACADEMIC ENGINEERING

Much of the research on female faculty and researchers we reviewed this year described problems and challenges. Cech and Sherick (2019) summarized results of a 2018 survey of 720 engineering faculty, all of whom were members of the American Society for Engineering Education (ASEE). Women faculty surveyed reported greater levels of marginalization and devaluation than male faculty. These differences were greater in departments in which the culture involved a strong commitment to “depoliticization” — i.e., the belief that social concerns such as inequality should be stripped from engineering to maintain its objectivity.

Miner et al. (2019) conducted two studies of early-career female STEM faculty at Texas A&M University to examine the effects of a chilly climate on their well-being. Their first study surveyed 96 early-career faculty, finding that early-career women were more likely than their male counterparts to experience ostracism (being ignored or excluded by others) and incivility (rude and discourteous behavior). In their second study, they

surveyed 68 female early-career faculty, finding that they reported more ostracism and incivility from male colleagues than female colleagues. The experience of a chilly climate had negative effects on feelings of well-being.

Minnotte and Pedersen (2019) used data from a climate survey at a Midwestern university to examine the effects of departmental environment on work/life conflict among STEM faculty. They found that psychological safety (the ability to express oneself without repercussions) and perceived departmental fairness in how faculty members are treated reduced feelings of work/life conflict. They found no gender differences in these relationships. Unfortunately, the researchers do not report on respondents’ overall feelings of work/life conflict, so it is not clear from their summary whether their male and female respondents had similar levels of work/life conflict or simply that the predictors of this conflict worked in the same way for both men and women.

Sattari and Sandefur (2019) conducted a study of 30 male STEM faculty at two Midwestern universities. Their goal was to explore how male faculty thought about the issue of whether gender makes a difference in academic STEM disciplines, with a view to assessing how likely it is they would be supportive of efforts for change. A near-majority of their respondents saw STEM as gender blind and felt the egalitarian structure of academia did not allow gender to make a difference. Those who disagreed fell into two camps: those who acknowledged male privilege and those who argued that both men and women share challenges, but recognized that they are somewhat more significant for women. Sattari and Sandefur conclude that unless a serious effort is made to engage with male faculty on gender issues, it is not likely that they will be supportive of efforts to promote change.

Similarly, Beddoes (2019a) presented a new typology of engineering professors’ “ways of not knowing” about gender in engineering and education. The typology was based on interviews with 39 engineering professors, men and women, at three universities in the U.S. Beddoes argues that understanding these ways of not knowing is important for developing future initiatives aimed at improving gender equity in engineering

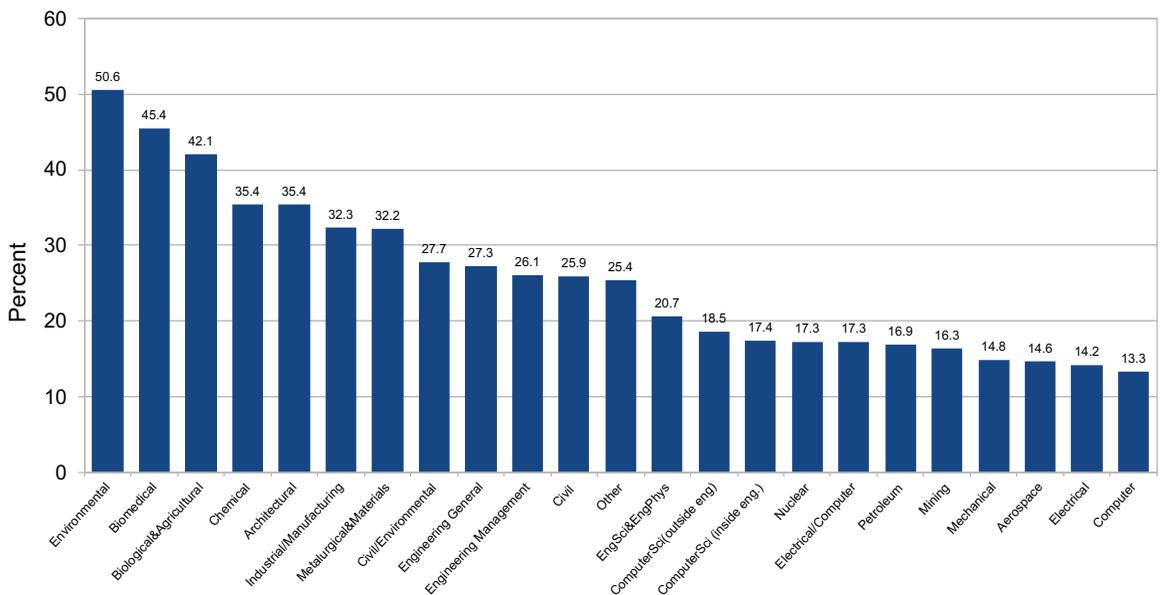
programs. However, this study was examining gender in the context of undergraduate education more specifically.

Several studies focused on differences between female and male faculty members' experiences of academic work. Macfarlane and Burg (2019) interviewed 30 faculty in the U.K. (half of whom were in STEM disciplines), confirming the now-familiar research finding that although both men and women prioritize research leadership, academic women are more likely than men to value the work of academic citizenship, including mentoring. They argue that this commitment to what they call "academic housework" — itself a somewhat disparaging turn of phrase — continues to hold back the careers of academic women. Zippel (2019) analyzed data from interviews with more than 100 STEM faculty and administrators at research-intensive universities in the United States regarding their ability to engage in international research collaborations. She found that it is more difficult for women to engage in these collaborations because gendered imagery creates "glass fences" that must be overcome. International collaborations were

not valued highly unless they resulted in external funding or prestigious publications and/or comported with a masculine image of the researcher as "exploiter," someone who was taking advantage of lower overseas research costs or using the collaboration solely to gain access to information. Zippel argues that it is easier for male faculty to engage in collaborations that fit this pattern.

Dengate et al. (2019) found gendered differences in attitudes toward tenure criteria among Canadian STEM faculty that may be related to these gendered differences in work experience. They surveyed more than 400 STEM faculty at four Canadian universities finding that, while both felt the criteria for tenure needed to be broadened to recognize teaching and service more fully, male faculty were more likely to support the traditional model of academic success than women. Among women, there was significant, although not majority, support for what the researchers call a "progressive" model of tenure, which involved a complete revision of the value system underlying tenure, not just changing the weight given to service or teaching.

Percentage of BS Engineering Degrees Awarded to Women by Discipline, 2018



Source: Roy, Engineering by the Numbers, American Society for Engineering Education, 2019

ENGINEERING PRACTICE

As noted in the introduction, we read a larger than usual amount of research on engineers working outside the academy this year, something we have been urging for several years. As with research on academic engineering, much of this research focused on negative aspects of women's working experiences, although attention also was paid to the ways in which women cope.

Tao and McNeely (2019) analyze data from the National Science Foundation's Scientists and Engineers Statistical Data System (SESTAT) database on graduates in engineering and science to look at

whether degree recipients are working in engineering. They studied those who received engineering degrees in 1993, 2003, and 2013. Overall, they found that only 59% of graduates were working in engineering occupations, with slightly lower persistence rates for women. Persistence rates for both men and women were lower for the most recent two cohorts studied, with women's persistence rates declining somewhat more. There were variations by race as well, which we discuss below in the section on intersectionality. Among both men and women, change in career interests was one of the top two reasons for leaving engineering; however,

The ARC Network: A STEM Equity Brain Trust

In 2017, the National Science Foundation (NSF) awarded almost \$5 million (Award HRD-1740860) to the Association for Women in Science (AWIS) to support the ADVANCE Resource and Coordination (ARC) Network Building on the work of NSF's ADVANCE program, the ARC Network seeks to promote systemic change to address gender equity in the STEM professoriate.

Since 2001, NSF has invested almost \$300 million to support ADVANCE projects aimed at increasing the representation of women in the STEM workforce. The ARC Network seeks to collect, analyze, and broadly share the knowledge created by the multitude of researchers funded by NSF ADVANCE. By connecting scholars and practitioners, the ARC Network is intentional in its efforts to improve the participation, advancement, and inclusion of diverse women in STEM. Online resources and stakeholder meetings facilitate the application and adaptation of the ADVANCE research for practical use.

To support the translation of research to practice, the ARC Network includes two components: community and research. The Society of Women Engineers (SWE) is proud to be an active ARC Network member as a representative of both the communities of practice and the research board. SWE's participation is an opportunity to help inform change efforts to improve gender equity in STEM by encouraging research-based applications in real-world contexts.

One of the major products of the ARC Network Community to date has been the development of a rich

library of curated gender equity in STEM resources.

The ARC Network Resource Library, including reports, white papers, toolkits, and other materials produced by researchers and practitioners, and the library continues to grow with contributions from network members. Join the community at www.EquityInSTEM.org and gain free access to these resources. Membership is free, and members have the opportunity to participate in a variety of virtual and in-person workshops and community collaborations.

Another important activity of the ARC Network is the Virtual Visiting Scholars program. Each year, members of the ARC Network Research Board select researchers to conduct meta-analysis, synthesis, and big data curation centered on STEM faculty equity. To date, five scholars have been selected, focusing on topics related to issues including mentoring women faculty of color, STEM faculty networks through an intersectional gender lens, and the effects of gender and intersectionality on citation practices.

The ARC Network also hosts a Community Convening each year, where members from higher education, industry, nonprofit, and government share research, resources, and best practices for STEM equity. You can learn more about the ARC Network, join to participate in future events, and have access to valuable research available through the online resource library at www.EquityInSTEM.org.

while men also emphasized pay and promotion opportunities, women were more likely to say they left because a job was not available. Among those who left, men were more likely than women to have moved to computer science; women were more likely than men to have left STEM altogether.

Research in the Netherlands conducted by van Veelen, Derks, and Endedijk (2019) suggests that being “outnumbered” may contribute to women’s discomfort in some STEM fields. They surveyed 807 STEM graduates (of whom 177 were women) and found that feelings of gender identity threat increased the more women were outnumbered by men in their direct working environments (something that is highly likely in engineering workplaces).

Beddoes (2019b) presented findings on the biggest challenges faced by first-year practicing civil engineers in the U.S. Based on interviews with 12 women and six men, Beddoes (2019b) found that while both men and women experienced interdependence and learning new practices and material as their biggest challenges, negative interpersonal interactions in the form of harassment and being ignored were cited only by women as their biggest challenge. In fact, negative interpersonal interactions were not mentioned by any of the men anywhere in the interviews. The takeaway is that although both men and women newcomer civil engineers struggle with some of the same things, for some women there is an extra layer of challenges to navigate on top of the challenges they share with men.

Williams’ (2019) study of the oil and gas industry points to the role employers can play in pushing women away from engineering. She interviewed 356 engineers and scientists who worked for a multinational oil company between 2014 and 2017. During an economic downturn in the industry, layoffs became inevitable. Williams found that, despite the official position that layoffs were based on skills and performance ratings, a discourse of the “deserving professional” affected layoff decisions in ways that disadvantaged women.

She discovered that managers were reluctant to lay off “deserving professionals” — native-born whites, who were under the age of 50 and were identified as the family breadwinner. Part-time workers, many of whom were women with small

children, were particularly likely to be laid off.

Cech and Blair-Loy used the 2003-10 survey waves of NSF’s SESTAT database on science and engineering graduates to examine the career trajectories of new parents. They found that both men and women often leave full-time STEM employment after the birth of their first child, but that women are considerably more likely to do so: 43% vs. 23%. Nonparents were significantly less likely to leave STEM employment, indicating that work/family issues continue to be a significant factor in causing STEM professionals, particularly women, to leave their jobs.

Sociologists of work, following the pioneering research of Christine Williams (1989), have long recognized that gender segregation is sometimes shaped by “glass escalators” that lead women and men out of occupations traditionally dominated by the opposite sex. Alegria (2019) interviewed 32 women engaged in tech work (the production, design, and maintenance of computer hardware, software, and networks) to determine if a glass escalator existed, moving them into managerial roles where the required “interpersonal” skills matched gender stereotypes. She found some evidence of this, although the effect was weak enough that she describes it as more of a “step stool” providing only a small lift. And, she found that it did not exist for women of color, none of whom experienced the kinds of unsolicited or unexpected promotions several of their white colleagues experienced.

The studies reviewed above analyze women’s departures from engineering jobs. Several studies we read this year focus instead on things that enable women to stay, even when they have negative experiences. Fernando, Cohen, and Duberley (2019) interviewed 50 women, at various stages of their careers, who worked at three companies in the British petroleum, mechanical, and automotive engineering sectors. Respondents agreed that female bodies attracted undue attention in their workplaces; they described the various strategies they adopted to navigate this “sexualized visibility.” Some early-career women used the strategy of confirmation, positioning themselves as daughters or sisters to avoid sexual provocation, while others embraced their gender and challenged stereotypes by demonstrating high levels of competence (en-

hancement). Midcareer women tended to engage in avoidance, playing down their femininity to neutralize the possibility of sexual attraction, while some women at all career stages tried to “assimilate” by adopting stereotypically masculine behavior (a strategy that worked best for late-career women). The authors note that, while these strategies helped women navigate their workplaces, they tended to reinforce gender stereotypes.

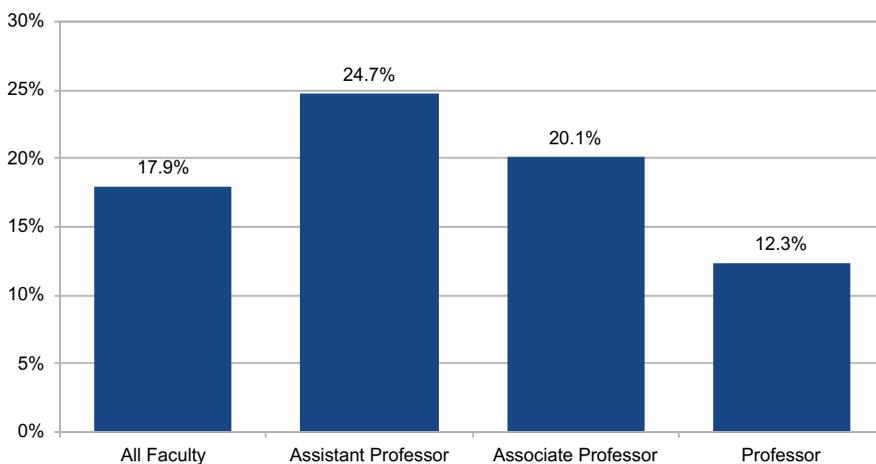
Dutta (2019) reports on a study of 45 women employed as STEM professionals in Singapore. She describes how the women studied construct stories about their experiences and anticipated experiences and coping strategies to navigate obstacles they experience as women in traditionally masculine fields. The author finds that resilience is not something women develop in response to a sudden event — rather it is constructed on an ongoing basis, both in response to events and in anticipation of problems to come. The stories women develop allow them to cope with challenges as they arise and to communicate resilience to other women in the workplace.

Khilji and Pumroy (2019) also describe the strategies female engineers used to cope in male-dominated workplaces. They interviewed 10 female engineers working in a variety of industries. All described the gendered norms of their organizations and several volunteered stories about experiencing discrimination, both overt and

covert. They employed various coping strategies, ranging from conforming to the rules, to negotiating to get around the rules, to defiance to establish their own rules. The authors don’t offer an analysis of which strategy works best or whether there are patterns determining which women adopt which strategy. But, they make the important point that the women they interviewed were not passive in the face of organizational realities; they had “agency” and had been successful in using it to deal with the challenges they had faced.

These studies of working engineers in academic and nonacademic workplaces document the existence of gendered workplaces in which it is not always easy for women to make their way. The late-career and retired women engineers surveyed by Ettinger, Conroy, and Barr (2019) attest to the degree to which gender is deeply embedded in the interactions and social structures of engineering workplaces. Like the women in the studies describing how women “cope,” Ettinger, Conroy, and Barr’s respondents tended to rely on individual-level solutions, to emphasize the need to be strong, to persist, and to find a way to “just do it.” As we will see in our concluding discussion of “what works,” there is a case to be made that the gender integration of engineering will require more than individual solutions that focus on “improving” or “changing” women.

Women as % of Tenured/Tenure-track Faculty by Rank



Source: Roy, *Engineering by the Numbers*, American Society for Engineering Education, 2019

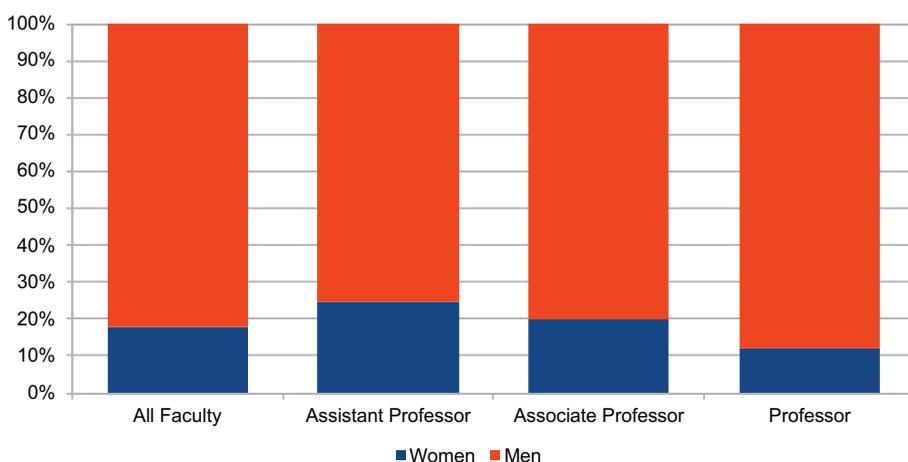
INTERSECTIONALITY

As in recent years, we again wish to highlight studies with important new intersectional findings and/or approaches. The first such study employed an experimental design to test whether participants evaluate and pay an Asian American woman job applicant differently depending on whether her gender or race is made more prominent on the application. Rattan et al. (2019) present the results of three different experiments in which they had women and men participants (university students as well as adult nonstudents) evaluate a fake application for the positions of computer technician, tutor in computer science and English literature, and computer programmer. They found that the Asian American woman was evaluated differently depending on which aspect of her identity potential employers perceived as the most salient. Specifically, men rated the applicant as more skilled and more hireable and offered her higher pay in the computer-related positions when her race, rather than her gender, was made salient. The reverse was true as well; when her gender was made salient, men rated her less skilled and less hireable for those positions. While the studies did have some noted limitations, including small sample size and not being able to definitively determine which identity drove the different evaluations, they raise complex questions about how to reduce biases in hiring and pay decisions.

Furthermore, as the authors point out, it will also be important for future research to explore these same questions for women who have identities in two negatively stereotyped groups, i.e., Latina women and African American women. Future research should also consider the complexity of racial identities as they intersect with gender. Research by Williams, George-Jones, and Hebl (2019) found that not just race but stereotypical appearance affected students' likelihood of persisting in STEM (e.g., Asian American students who looked stereotypically "Asian" were more likely to persist, while African American students whose appearance was more stereotypical were less likely to persist). This study did not consider gender, so there is an obvious need to see what an intersectional approach would find.

Another innovative intersectional study by Kargarmoakhar and Ross (2019) presents findings about four Muslim women's pathways into their chosen field and factors that affected their choices. Based on interviews with students in a computer science Ph.D. program at one public university in Florida, they found that the most relevant factors to the participants' choosing computer science were cultural factors and family impact. While the significance of family on women's STEM pathway decisions has long been documented, a new finding that emerged from this study is that the participants chose computer science, as opposed to

Engineering Faculty by Rank and % Gender



Source: Roy, *Engineering by the Numbers*, American Society for Engineering Education, 2019

other engineering fields, because they perceived it as a more feminine field. That contrasts with the dominant view of computer science as a masculine field in the U.S., thus highlighting how the gendering of certain fields varies by culture.

There were also several intersectional studies exploring the experiences and pathways of women of color that stood out this year, two of which came from a special issue of the *International Journal of Gender, Science and Technology* devoted to intersectionality and edited by Moncaster and Morris (2019).

The first large national survey in this group of papers was Tao and McNeely's (2019) analysis of engineering workforce pathway data (from the U.S. SESTAT database) for the 20 years between 1993 and 2013 (discussed above). They identified intersectional patterns that would not have been seen without specific attention to race/ethnicity.

For example, white American men are retained in engineering careers at the highest rate, while Asian American women are retained at the lowest rate. For women specifically, white American and Hispanic American women are retained at higher rates than African American and Asian American women. The study also identified many differences in reasons for leaving among different groups of women and men, with white American women most likely to leave because of a change in career interests and family-related reasons, and African American and Hispanic American women most likely to leave due to the job they wanted not being available to them and a change in career interests.

Based on a survey of 2,104 women of color engineering students at 18 research-intensive universities in the U.S., Ro and Kim (2019) analyzed self-reported critical thinking, research,

Collaborative Network for Engineering and Computing Diversity

The Collaborative Network for Engineering and Computing Diversity (CoNECD; pronounced "connected") conference — "the only conference dedicated to all the diverse groups that comprise our engineering and computing workforce" (ASEE Education and Career Development, 2019) — was held for the second time in 2019. This year's conference brought together 326 educators and researchers for 79 sessions, up from 70 sessions last year.

Unlike many other conferences that focus on one population in engineering, CoNECD presentations cover the experiences of "women, individuals of diverse racial, ethnic, and socio-economic backgrounds as well as varied gender identities and expressions, the LGBTQ+ community, people with disabilities, veterans, and first-generation college students" (CoNECD, 2019). Also, by accepting peer-reviewed presentations in addition to peer-reviewed papers, CoNECD provides an important venue and forum for practitioners to share practices.

In 2018, the conference tracks were focused mainly on individual identity groups (i.e., there was a Gender track and a Race/Ethnicity track), which proved to be frustrating to authors of intersectional work and their audiences. A change was made, and in 2019, the sessions were organized into five tracks and six special topics.

The tracks were Pre-college; Collegiate; Graduate; Faculty; and Learning Spaces, Pedagogy and Curriculum Design. The special topics were Identity; Computing and Technology; Social Justice and Reform; Evaluation and Grant Writing; Student Organizations; and Intelligence (CoNECD, 2019).

The conference was co-hosted by the National Association of Multicultural Engineering Program Advocates (NAMEPA), the Women in Engineering ProActive Network (WEPAN), and the Minorities (MIND) and Women in Engineering (WIED) divisions of the American Society for Engineering Education (ASEE). The event's 2019 organizing committee included Darryl Dickerson, Ph.D., president, NAMEPA; Catherine (Kitty) Didion, executive director, WEPAN; Beena Sukumaran, Ph.D., past division chair, WIED; Beville Watford, Ph.D., immediate past president of ASEE; and Rochelle Williams, Ph.D., chair, MIND (CoNECD, 2019).

ASEE Education and Career Development (2019). CoNECD Marketing Kit. Retrieved from: <https://sites.google.com/avt.edu/conecd/opportunity-for-sponsorship>

CoNECD (2019, April). CoNECD conference program. Retrieved from: https://cdn.ymaws.com/www.wepan.org/resource/resmgr/conference-change-forum/2019-conecd/conecd_2019_program.pdf

communication, and professional skills, as well as the effects of curricular, pedagogical, and co-curricular experiences on those skills, for four groups of women: Asian; black and other; Latina; and white. The only differences identified were that, compared with white women, Asian women rated their skills/learning outcomes in all four categories significantly lower, and black and other women rated their critical thinking skills lower. The authors point to a continued need to oversample women of color, including Asian women who are often not seen as a minority group, in quantitative studies so that their experiences and outcomes can be better understood.

Yamaguchi and Burge (2019) analyzed data from 93 black women who work in computer science in the U.S. to identify intersectional themes in their experiences and identify needs specific to that group of women. The data included focus groups as well as a survey, and most participants were from academia rather than industry. The four themes/needs identified were: specifically link black women's (as opposed to underrepresented groups in general) recruitment, retention, and career growth to organizational/institutional and personal accountability; provide multifaceted cultural and educational supports for black women throughout the pipeline starting in middle school; provide opportunities for leadership development in school and workplaces; and collectively produce more research and scholarship specifically about, for, and by black women in computing.

Other research we reviewed echoed this emphasis on attending to the distinctive experiences of women of color in engineering. For example, Johnson et al. (2019)'s experimental study involving 351 black female students found that respondents who read a profile of a successful black professor at a hypothetical college of science and engineering reported greater anticipated belonging and trust than students who read a profile of a successful white professor.

Finally, Kang et al. (2019) employ an intersectional lens in their analysis of data on 1,921 middle-school girls in low-income communities in Michigan, North Carolina, New York, and Hawaii. The authors are interested in how middle-school girls develop STEM identities and whether race and

ethnicity play a role in this process. They found that, in general, girls' self-perception in relation to science was positively associated with experience of science at home, outside school, and in science classes. However, there were significant racial and ethnic differences in their results. Asian American girls showed the strongest identification with STEM-related careers, while African American girls showed weak identification in all domains except biological sciences. Asian American girls had the most experience with science at home, while African American girls had the least. The authors report that experience with science in the classroom alone is not predictive of identification with STEM careers; they advocate steps to expand girls' exposure to science in a variety of settings and emphasize that that exposure should be culturally relevant and context dependent.

INTERNATIONAL COMPARISONS

Many of the studies we reviewed this year considered the experiences of women in engineering and science outside the United States. As we noted in the introduction, some of these studies, particularly those focused on European countries and Australia, do not emphasize the comparative dimension — they make little effort to identify what is distinctive about the experience of women in engineering in a particular national setting, so we have discussed the findings of several of these studies elsewhere in this review. Other research *does* make a conscious effort to introduce a comparative dimension to the study of women in engineering, something we highlight in this section of the review.

Singh and Peers (2019), in their contribution to the special issue of the *International Journal of Gender, Science and Technology* mentioned above, propose a framework for classifying countries based on the involvement of women in engineering. They argue that countries can be classified into four categories:

1. Developed countries that were never communist/socialist
2. Former communist countries, plus countries in the Nordic and Levant regions
3. Developing countries at various levels of development

Diversity, Unrest, and Silicon Valley

The image of Silicon Valley firms as open, communal associations of engaged, satisfied employees has been tarnished in recent years, as allegations of sexual misconduct and a “boys club” culture made headlines. This year, the turmoil continued, with reports that the culture of open discussion at companies such as Google and Facebook were in jeopardy and that some companies were struggling with employee trust. Although the issues underlying these tensions were varied, they often intersected with the gender issues that had emerged in previous years.

In November 2019, Google fired four employees for what it said were “clear and repeated violations of our data security policies.” The four had been actively involved in labor organizing at the company, leading to claims that the company was engaged in union busting. In response, in December, the National Labor Relations Board (NLRB) launched an investigation of whether Google had broken the law in firing the four employees. Later in December, another Google employee, security engineer Kathryn Spiers, said she was fired for using a company tool to notify her co-workers of their right to organize.

The effort to organize workers at Google is rooted in a range of employee concerns, including discontent with the company’s involvement with the Department of Defense and concerns over its involvement with the Department of Homeland Security, which were intensified when the company hired Miles Taylor, a former member of the Department of Homeland Security staff. However, the organizing efforts also are linked to concerns about diversity and discrimination, most notably to dissatisfaction about the ways in which the company handled complaints of sexual harassment and the perception that it was protecting senior employees who had been accused of sexual impropriety. The organizing efforts follow a large-scale walkout by Google employees in 2018, protesting payouts to executives accused of sexual misconduct. The recent firings have also raised questions of gender and sexual equity — the majority of those fired were women, and at least two self-identified as LGBTQ. News media reported that some members of the company’s LGBTQ community felt unsafe at Google and had received electronic threats.

Google also was in the news for its 2018 firing of a male engineer, Kevin Cernekee, allegedly for his conservative

political views. Cernekee is an open, vocal Republican who spoke out internally on various occasions during his time at Google. Some of his comments are linked to the gender controversies plaguing the Silicon Valley, including James Damore, author of a widely reported memo arguing that men were better suited for tech jobs. He also posted on company sites defending a colleague who denied that there was gender bias in hirings and criticizing a feminist colleague for not being able to handle criticism. Cernekee was accused of multiple violations of company policies, but complained that his dismissal was political. His complaint received national attention, including comments by the Republican House minority leader. In September 2019, the NLRB settled the dispute with the company, calling on it to allow greater debate and more open discussion on campus. Media reports suggest that this did not create a political truce within the company, instead fueling tensions prior to the firings of the four union activists in November.

Also in 2019, the U.S. Department of Labor (DOL) brought suit against Oracle for what it said was widespread discrimination against women and people of color. The suit claims that the company systematically excluded African Americans and Hispanics in its hiring decisions and that women and people of color were paid significantly less than their white male counterparts. The company is accused of favoring Asian applicants in hiring, a group who were then underpaid (the DOL suggested that Asians’ dependence on the company for work authorizations enables this underpayment). Women, African Americans, and Hispanics also were found to be underpaid, with the gap between them and white male employees growing with tenure at the company. An earlier suit, filed in 2017, estimated that the company owed employees as much as \$400 million in compensation for these inequities. The new suit suggests that Oracle had not changed its practices, so the amount owed to underpaid groups of workers is now significantly more. Oracle denies the allegations, stating that it is in compliance with regulations and committed to equality. The company is reported to have sued the DOL to end the discrimination lawsuit, alleging the DOL’s actions had usurped the role of the federal courts in handling complaints regarding discrimination. While the issue remains unresolved,

these claims of gender and racial discrimination, the ongoing controversy over sexual harassment, and the tensions flaring up at companies such as Google present a picture of the Silicon Valley as a place where diversity has become a flashpoint for conflict.

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4. Countries of the Middle East and North African regions, plus the Levant

The authors use this scheme to note differences in women's participation in engineering. For example, they find that women's participation in category one tends to hover between 10 and 20%, while it is much higher (but declining) in many of the countries within category two. Women's participation in engineering in category four is quite high, while it is variable in category three, in part because of limited access to higher education in those countries. The authors also note that affirmative efforts to increase the numbers of women in engineering tend to be concentrated in the countries grouped in category one. There are some obvious questions one can pose to this classification scheme (the Levant appears in two places, developing countries vary tremendously, the differences between Nordic countries and formerly communist countries are significant, etc.). Nevertheless, the authors draw attention to the reality that the numbers of women in engineering vary significantly in different countries and that the variations are not related in any simple way to levels of economic development, a point made quite persuasively in research summarized in last year's review.

Several studies we read this year described the experiences of women in Middle Eastern countries, which, as Singh and Peers' review makes clear, are countries in which female engineers are relatively common, despite strongly patriarchal cultural settings. Al-Aawi et al. (2019) review the situation of women engineers in Bahrain, where 43% of engineering graduates are women. Although Bahraini cultural stereotypes create barriers, and while employers prefer not to hire married women with children, and while most respondents agreed that employers prefer to hire male engineers, women represent a significant portion of the engineering workforce. They are 35% of public sector engineers, 21% in the private sector, and respondents expressed a high degree of confidence in their ability to succeed as engineers.

Not all Middle Eastern countries appear quite as open to working women engineers, however. Mozahem et al. (2019) interviewed female engineering students in Lebanon, finding that female engineers

face significant hurdles in both professional and social settings and that family and friends often question their choices. Houjeir et al. (2019) report on women in STEM higher education in the United Arab Emirates. Women outnumber men in the three UAE universities studied, and constitute about half of the engineering students at one of them. But the researchers report that women in the UAE have little incentive to join the workforce after graduating and that family priorities and a culture of modesty requiring the separation of women and men makes their involvement in engineering work a challenge.

One other study on a predominantly Muslim country, this time not in the Middle East, is Edirisinghe and Cheok’s (2019) study of female research engineers in Malaysia. Women make up almost half of engineering students in Malaysia, and outnumber men in other STEM disciplines. However, the researchers report that the women to whom they spoke tend to see work as a steppingstone to marriage and were more concerned with work/life balance than with advancing their careers.

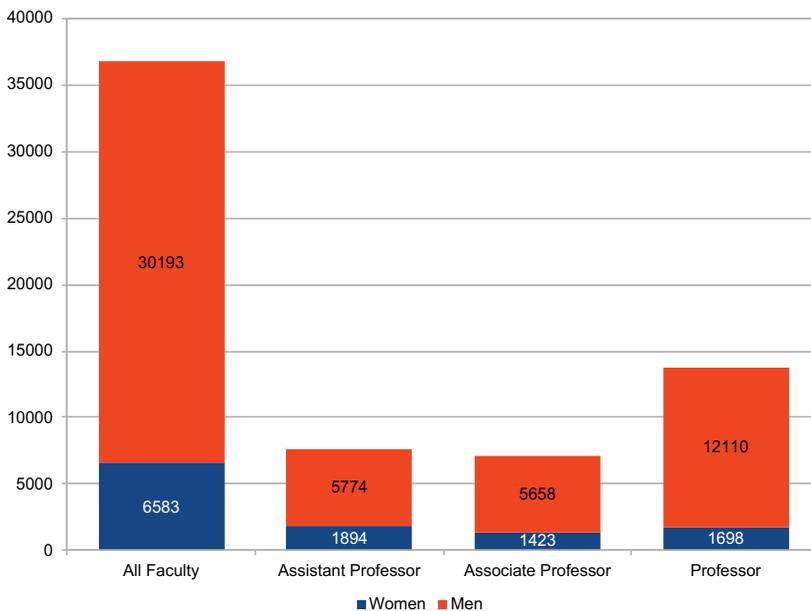
Rincon, Korn, and Williams (2019) present findings on the state of the engineering workplace for

women in India. Based on 693 survey responses (61% women, 39% men ages 25-43), Rincon et al. found that women in India faced the same well-documented gender bias challenges as women in Western countries, with similar effects on their careers. However, they note that there are distinctive features to the experience of bias among female engineers in India. Specifically, they found the experience of “tug-of-war” bias, in which gender bias leads to tensions among women, to be more common in India. Rincon, Korn, and Williams also describe women’s ambivalent response to the Shops and Establishments Act, which was intended to protect women by prohibiting late-night work. Many said that they had experienced negative effects because of this law, but others talked about how it made work/life balance easier to achieve. They also found that while women faced gender biases, men faced biases related to where they were from and the language they spoke.

MEN AND MASCULINITIES

There was one relatively new emphasis in the literature on diversity in engineering we reviewed this year: research on men and masculinities in

Engineering Faculty by Rank and Gender



Source: Roy, Engineering by the Numbers, American Society for Engineering Education, 2019

engineering. Given the interest in men as allies in the effort to increase gender diversity in engineering, this is a promising research direction. In addition, understanding masculinity in engineering may further understanding of the obstacles women in engineering encounter, since many researchers have found the masculine culture of engineering to be the most significant barrier women engineers face.

We have already noted several studies that compare women's and men's experiences, as well as Sattari and Sandefur's (2019) study of male faculty's perceptions of gender bias in engineering. Other research comparing men and women in engineering in the university context included a paper by Pla-Julián and Díez (2019). They conducted a survey of four groups of students in Spain (men and women engineering majors, and men and women humanities/social science majors) to determine students' perceptions of societal-level gender equality and the importance of efforts to promote social equality. Compared with the other three groups, the men engineering students — inaccurately — perceived the most social equality between men and women, and they were the group that rated the importance of efforts to promote gender equality lowest. This is troubling indication of some of the difficulties faced by those working to advance women in engineering in Spain.

In another comparative survey, this time of engineering students at three universities in Canada, Denis and Heap (2019) identified several differences between men and women: Women were significantly more likely to have had an A average in the previous year (40% vs. 26%), and significantly more women held leadership roles in engineering or technical societies (30% vs. 10%); but men were more likely to participate in engineering competitions and to find that participation encouraging. However, overall the authors noted many similarities between men and women in terms of their perceptions of support for students, having an influential role model or advisor, and family backgrounds. This survey was one part of a larger mixed-methods study with data collected between 2004 and 2008.

Another new research direction for students of gender in engineering is exemplified by Danielsson

et al.'s (2019) research examining the experiences of four “working class” men mechanical engineering students in Sweden. This study utilized ethnographic observations, interviews, and video diaries to better understand the socially and discursively constructed identity work done by the participants navigating their engineering program. The authors found that while a norm of “technicist” masculinity easily aligned with participants' identity trajectories, the norm of “laddish” masculinity created a “troubled” identity trajectory for one participant. The study also revealed that project work was difficult to incorporate into some of the students' identity trajectories. By identifying different types of masculinities, and linking them to social class, this article demonstrates the need to study men, not just women, in order to advance understandings of gender in engineering, which has been a prominent gap in gender research in engineering (Beddoes, 2019c).

Research on men and masculinities in engineering was encouraged, this year, by the publication of a special issue of *Engineering Studies* on men and masculinities in engineering edited by Kacey Beddoes (2019c). Several of the articles reviewed here (Danielsson et al.; Pla-Julián and Díez; Ettinger et al.) were included in that special issue. In another article from that same collection, Secules (2019) reflects on his own ethnographic observations of masculinity, competition, and competition-as-masculinity in engineering education through historical lenses. He problematizes often unseen and taken-for-granted aspects of masculine engineering education culture and summarizes historical literature to frame the findings. He notes how engineering has been “constructed” as identity-less — “Engineering is quintessentially colorblind and class-blind and gender-blind — it just happens to be occupied consistently by middle-class straight White able-bodied men.” (199)

Within this frame, the relative absence of women seems unremarkable, and the emergence of women and minority group members in engineering represents the appearance of a mysterious “other” who constitute a problem of integration. Secules also stresses the role played by competition in constituting engineering as male. He notes how competition is an important part of engineering

Female Deans and Directors of Engineering Programs in the U.S.

Cammy R. Abernathy, Ph.D., dean, University of Florida

Alexis R. Abramson, Ph.D., dean, Dartmouth College

Stephanie G. Adams, Ph.D., dean and Lars Magnus Ericsson Chair, The University of Texas at Dallas

Nancy Allbritton, Ph.D., Frank and Julie Jungers Dean of Engineering, University of Washington

Emily L. Allen, Ph.D., dean, California State University, Los Angeles

M. Katherine Banks, Ph.D., vice chancellor and dean of engineering, Texas A&M University

Gilda A. Barabino, Ph.D., dean, City College of the City University of New York

Susamma Barua, Ph.D., dean, California State University, Fullerton

Stella N. Batalama, Ph.D., dean, Florida Atlantic University

Joanne M. Belovich, Ph.D., interim dean, Cleveland State University

Christina Bloebaum, Ph.D., dean, Kent State University

Barbara D. Boyan, Ph.D., dean, Virginia Commonwealth University

Mary C. Boyce, Ph.D., dean, Columbia University

Bethany Brinkman, Ph.D., P.E., director, Sweet Briar College

JoAnn Browning, Ph.D., P.E., dean, The University of Texas at San Antonio

Janet Callahan, Ph.D., dean, Michigan Technological University

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education but has been found to be uncomfortable for female and minority students, who are drawn to more collaborative and cooperative learning environments. Readers may wish to consider Secules' article in combination with Amy Sue Bix's (2019) history of concrete canoe competitions and the growth of competition culture in engineering programs, which also appeared in *Engineering Studies*, and touches briefly on gender issues as well. It is to be hoped that research on masculinity in engineering will continue in future years, enabling a deeper understanding of the ways in which engineering culture is gendered.

WHAT WORKS?

As in previous years, many of the studies we reviewed focus on evaluating interventions designed to help increase the numbers of women in engineering and/or to support their progress within the profession. In summarizing this portion of the research literature, we would like to emphasize two important themes. First, several studies we reviewed this year raise the question of whether interventions designed to support women in engineering can have unintended consequences or even backfire in some ways. These studies need to be read critically, but do sound an important note of caution to which future research should attend. Second, we noted again this year an ongoing debate within the literature exploring how to encourage gender diversity in engineering between approaches that focus on equipping women to cope better with the conditions they encounter and approaches that call for structural changes to engineering itself. The emphasis on the role of psychological and attitudinal variables in explaining the underrepresentation of women in engineering is clearly linked to the former approach. But, if diversifying engineering requires changing engineering itself, then future research, and actions, will need to focus more on structural factors such as engineering's masculine culture, discriminatory practices, or the experience of harassment and bias.

UNINTENDED CONSEQUENCES

One important area of interest we observed in the literature this year were the outcomes of diversity and bias interventions, including negative, or unintended, outcomes. Martin and Phillips (2019) present findings from a series of six different experiments that compared the effects of “gender-aware” versus “gender-blind” interventions. By “gender-aware,” they mean emphasizing differences between men and women, and women’s unique attributes/qualities. By “gender-blind,” they mean emphasizing similarities between men and women. It is important to note that their participants were drawn from general populations and were not necessarily in STEM fields themselves. Martin and Phillips’ conceptualization of “gender awareness” as emphasizing women’s unique attributes/qualities is rather limited and essentialist, so this research should be treated with caution. Nevertheless, the upshot across the six studies was that, among men, gender-blindness related to and led to less gender stereotyping about women’s STEM competencies. However, the authors discuss many caveats, nuances, and cautions for interpreting and drawing implications from these findings. For instance, they recognize gender-blind approaches carry their own problems.

Pietri et al. (2019) looked at the effects of video interventions for diversity in STEM (VIDS) in a series of three studies that included participants from the general U.S. population as well as women scientists. On the one hand, the interventions increased bias literacy and lowered gender bias among both men and women, which was a desirable outcome. On the other hand, however, the interventions decreased women’s sense of belonging in the sciences and increased negative affect and social identity threat for women from the general population and women scientists, which was an undesirable outcome. Negative sense of belonging was mitigated by the inclusion of a woman scientist as a role model, but stereotype threat was not. The authors conclude that, “Interventions (such as VIDS) that increase bias literacy therefore unintentionally may act as an external cue that increases women’s social identity threat. Although such interventions can help address one problem

(bias), they also may increase another (social identity threat), further exasperating gender disparities in STEM” (p. 529).

In a survey study from the U.K., McCarthy et al. (2019) analyzed data from 700 employees (22% women) at three civil engineering companies to determine if there was a relationship between perceptions of overall fairness in the company and attitudes toward equality initiatives. They found that there was indeed significant correlation between the two, suggesting that responses to and outcomes of equality initiatives for underrepresented groups may depend, at least in part, on how fair the organization is perceived to be overall. The authors conclude that without first addressing overall perceptions of fairness, equality initiatives may be “short-sighted and dangerous.” We would add that this conclusion raises interesting and difficult questions about potential tensions or incompatibilities in that approach, however, given that fairness is not an objective concept and dominant groups typically get to define what is fair (Beddoes & Schimpf, 2018). For example, parental leave is often seen as unfair by men in STEM academic departments (Beddoes et al., 2013); yet, that is a common gender equality initiative.

Some of these studies are experimental, and such studies must be read with a critical eye to see if the intervention bears similarities to the types of interventions taking place in engineering programs and workplaces. For example, Lewis, Sekaquaptewa, and Meadows (2019) conducted experimental research with 143 STEM majors at a large Midwestern university to examine the effects of exposure to a counter-stereotypic video on gender gaps in verbal participation in mixed-gender teams. They found that students exposed to the counter-stereotypic presentation had groups that showed relatively equal gender participation, while those who saw the stereotypic presentation had groups in which men dominated. This is suggestive evidence, but one must ask whether the brief exposure involved would have a similar effect in real workplaces, where traditional gender roles remain in place and where male team members may also have seniority and greater power.

CHANGE THE WOMEN OR CHANGE ENGINEERING?

Many interventions designed to promote gender diversity in engineering focus on women themselves. They seek to do things such as bolster women's feeling that they "belong" in engineering, to encourage women to be more confident about their skills and abilities, and to provide them with resources to compensate for advantages their male colleagues may have had. A report on collaborative work done by DiscoverE and the Concord Evaluation Group, *Despite the Odds: Young Women Who Persist in Engineering* (2019), illustrates well this type of intervention. The report seeks to identify the primary reason girls choose to pursue engineering and the factors that affect whether or not they persist. Their review of the literature points to a series of characteristics of women themselves: demonstrating an interest in and positive attitudes about engineering, seeing value in the profession, demonstrating engineering self-efficacy, embracing a STEM identity, and feeling a sense of belonging, and identifies examples of interventions that might help young women interested in or already involved in engineering to develop them. They also identify resources outside the workplace (support networks, social capital) that can help women succeed in the profession. For the most part, the review says little about engineering itself or about how it might become more welcoming to women.

Diekman, Clark, and Belanger (2019) adopt a similar approach in their effort to identify common ground in the wide-ranging literature on women in STEM. Their review notes that there are multiple, competing explanations for women's underrepresentation; what they see as common among the various theories is an emphasis on the incongruity between women and STEM and on the incongruity between STEM and student values. Based on this, they recommend interventions that challenge stereotypes, align STEM activities with students' values, and cultivate growth mindsets related to STEM ability. With the partial exception of the second strategy, these intervention tactics focus on adapting women to engineering, rather than on the reverse.

This approach seems to build on attitudes we read about in several of this year's studies of female

engineers. We have already summarized Ettinger, Conroy, and Barr's (2019) study of late-career and retired female engineers, which found that they adopted and advocated an individualistic approach to dealing with the challenges of being a woman in engineering. Myers, Gallaher, and McCarragher (2019) also describe women in STEM who see gender diversity through an individualistic lens in their study of 45 undergraduates at a large Midwestern university. They call the approach they encountered "STEMinism," in which women recognize gender differences and inequalities, but don't problematize gender power dynamics; from this perspective the solution to the problem involves individual women helping themselves. Nash and Moore (2019) discovered a similar set of attitudes among the 25 aspiring female STEM leaders from five countries whom they interviewed. They found that these women recognized sexism and gender bias in their organizational context, but at the same time described science and engineering as gender neutral. They made considerable use of the "lean in" vocabulary to explain organizational success; the lean-in approach has been found by Chrobot-Mason, Hoobler, and Burno (2019) to be effective at times, but also to present dangers, since others may not be accepting of women who lean in ('he's aggressive, she's pushy...').

Not everyone agrees that engineering or STEM more broadly are meritocratic and gender neutral, or that an individualistic approach to change will be effective. Virginia Valian (2019), for example, writes of the need to collectively find ways to combat harassment and abuse in the workplace. Greider et al. (2019), writing in *Science*, summarize a policy forum held at Cold Spring Harbor in late 2018 (Valian was a participant in this forum as well) that recommended a series of efforts to end harassment and improve outcomes for women, most of which involved changing organizations, not just individuals: institutional sanctions for those who are found guilty of sexual harassment; transparency in start-up packages, salaries, and internal grant funding, etc.

Programs such as NSF ADVANCE also reflect a more structural approach to achieving gender diversity since Institutional Transformation grants, by definition, focus on changing departments and

institutions. Of course, a more structural approach does not guarantee complete success, as two reviews of ADVANCE published this year make clear. Rosser et al. (2019) summarize the effects of NSF ADVANCE, as well as the Athena SWAN program in the U.K., finding that while progress has been made in both countries, attributing those successes to these programs is difficult, particularly in the case of Athena SWAN. They also note that sustainability has proved to be a challenge.

Zippel and Ferree (2019) also review the ADVANCE program in a provocative article in *Gender, Work and Organization*. They argue that while ADVANCE has had some success, it has been limited by the contradictory voices to which it had to attend. They identify tensions among the interest in gender equality that animated the program in the first place, the managerial interests that had to be satisfied to get universities to buy in, and the norms of scientific knowledge production that were imposed by the program's location in NSF. These conflicting influences have tended to focus the program on measurable results that are consistent with university priorities (e.g., research productivity) and to place an emphasis on publishable results, which is often difficult for single-site projects or for studies that involve conclusions that make people uncomfortable. None of this means that programs like ADVANCE are bad ideas or failures; but these reviews do indicate that even large-scale programs that focus on institutions need to be reviewed critically.

We conclude by noting a thought-provoking approach described in a small-scale study (Petray et al. 2019) of an Australian program intended to engage girls in STEM. The program involved drone-flying camps at two locations in Northern Australia. The camps were designed to provide girls with an opportunity to try flying and coding mini drones and to engage with peers and role models. What is innovative about this program is its approach to recruitment. While it attracted girls with STEM interests, it made a conscious effort to attract girls who did not already have a strong STEM identity or record of academic success in science or math. About half of the participants listed the arts and humanities as their favorite subject area. The authors praise this approach,

arguing that it challenges the “pipeline” metaphor they believe limits the recruitment of women into engineering by focusing on only one source of potential recruits. In their view, the secondary school curriculum creates a structural barrier against girls entering STEM by prioritizing the early possession of “hard” knowledge in STEM (which can be acquired later) over “soft” skills such as creativity, innovation, and artistic ability. Not only would more women be attracted to STEM disciplines if those disciplines were more attuned to the value of these skills, and more welcoming of people who had them, but STEM disciplines would be enriched by the resulting changes: an increased emphasis on teamwork, creativity, and communication. This small intervention demonstrates what “changing engineering” might involve, and why it could benefit both women and the profession itself.✱

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Fixing the “Broken Rung” in the Ladder to Success

Women have made great strides in attaining C-suite status — as chief executive officers, chief financial officers, and chief operating officers — but, according to a recent study, they’re still underrepresented at a vital stage — the entry management level.

By Sandra Guy, SWE Contributor

There is a “broken rung” in the ladder to success, and fixing it is key to women’s achieving parity in the workplace, according to the McKinsey & Company “Women in the Workplace 2019” report (<https://womenintheworkplace.com/>).

“If [companies] were better able to hire and promote to first-level manager, we could add 1 million more women to corporate management in the next five years,” said Jess Huang, a McKinsey partner and one of the report’s authors. “For every 100 men promoted to first-level manager, only 72 women enjoy that same success,” she said. “So men end up holding 62% of managerial positions versus women at 38%. This is a big issue that we need to fix to get to parity.”

This early inequality has a long-term impact on the talent pipeline. Because men significantly outnumber women at the management level, there are significantly fewer women to hire or promote to senior managers. The number of women decreases at every subsequent level until the C-suite, the report showed. Even as hiring and promotion rates improve for women at senior levels, women as a whole can never catch up. There are simply too few women to advance.

The situation shows glaring differences by race, as well as by gender. Only 12% of the employees at the manager level were women of color, and 17% were men of color, according to data submitted by the companies that responded to the survey.

SCOPE AND RECOMMENDATIONS

The 2019 Women in the Workplace report comprised workplace-experience surveys of more than 68,500 employees, as well as HR practices surveys of 323 companies that together employ more than 13 million people. For additional insights, interviewees included women and men of different races and ethnicities, LGBTQ women and men, and women with disabilities at all organizational levels.

The report uncovered another disconnect outside of a numerical one: Insiders’ interpretations — or misinterpretations — of a company’s priorities may serve as a barrier to women’s promotions. The report revealed that human resources department leaders are more likely to say achieving goals, strong leadership, and being good at managing people are the highest priorities. Employees, however, said they believed that their organizations most value navigating internal politics and being well-liked.

As a result, employees who are up for manager positions may be evaluated based on both official and unofficial requirements. To eliminate this disconnect, leaders should clearly communicate what really matters in their organizations — meeting goals and being effective leaders, the report said.

The 2019 findings build on data from the past four years of similar studies, as well as research that McKinsey & Company started in 2012. The five years of research have resulted in best practices for supporting and promoting women in the workplace.

The policies that work well require a company to:

- Ensure that women obtain the tools they need to become managers, such as leadership training, sponsorship, and high-profile assignments.
- Set and publicize a bold goal to increase the number of women at the management level. Diversity targets for hiring and promotions ensure



that the processes work to shape employee representation.

- Require diverse slates of candidates for hiring and promotions at the management level.
- Establish clear and consistent evaluation criteria before review processes begin.
- Require unconscious bias training for employees who are involved in entry-level hiring and performance reviews.

Given that hiring and promotions are powerful levers in driving pipeline diversity and employee satisfaction, there’s a strong business case for adopting these best practices, the latest McKinsey report concluded. At the heart of such initiatives’ success is not numerical change, but behavioral and attitudinal change, especially by bosses who can help their employees climb the career ladder, the report said.

EMPLOYEE EXPERIENCES AND PERCEPTIONS

Fewer than half of the women and men surveyed said they believe the best opportunities go to the most deserving employees, and fewer than a quarter said that only the most-qualified candidates are promoted to manager. On both fronts, women are less optimistic than men.

About a third of the employees said managers advocate new opportunities for them a great deal, and fewer than a quarter said managers regularly help them manage their careers.

Fewer than half of employees at the management level or higher serve as sponsors, and only one in three employees said they had a sponsor.

“Given that fairness and opportunity are so critical to employee outcomes, companies should be encouraging managers — who play a key, everyday role in shaping employees’ day-to-day experiences — to challenge bias,” Huang, one of the report authors, said. “Empowering people at the manager

Case Studies

The report outlines specific steps and case studies of companies succeeding at supporting and promoting women, particularly at the upper rungs of management. One example is JP Morgan Chase, which launched what it calls the 30-5-1 campaign to encourage employees to support female colleagues. The program encourages employees to set aside 30 minutes a week to have coffee with a valued female colleague; five minutes a week to recognize a female colleague’s success; and one minute a week to share that success with others at the company.

Yet another key to strengthening women’s roles is to combine specific programs with an inclusive work environment, said Cindy R. Pace, Ed.D., vice president and global chief diversity and inclusion officer at MetLife. “It’s not ‘do one thing and everything will fall into place,’” said Dr. Pace, who started at MetLife in 2013 to lead the company’s global women’s initiative. The initiative remains core to the insurer’s business strategy.

“We are putting diversity and inclusion at the center — as core to our values, to succeed together,” Dr. Pace said. She has overseen the women’s initiative’s expansion. It includes three programs:

International Women’s Day Forum, an annual web-cast that creates an understanding of what it means to innovate for change. It also delves into what people can do to continue creating innovative solutions that foster collaboration, build inclusion, and engage customers throughout the world.

The forum also celebrates the contributions of women globally and lets employees around the world connect with influential thought leaders. MetLife announced at the 2019 event that it is the first insurer to join the UN Women Global Innovation Coalition for Change. The coalition is a partnership between UN Women and key representatives from the private sector, academia, and not-for-profit institutions focused on developing the innovation market to work better for women and to accelerate the achievement of gender equality and women’s empowerment.

level, providing them with the right resources to address talent and bias, is critical.”

Finally, employees said they appreciated their employers’ efforts to offer time off for family reasons, flexible work hours, and the ability to work remotely. But they said companies can do more: Work/life flexibility was the number one issue that employees raised in the 2019 report, followed by the need for more mentorship and sponsorship.

Yet more than one in four employees who took leave said it hurt their careers or finances — and this was particularly true for women. Twenty percent of women who’ve taken a leave said it negatively impacted their careers, compared with 10% of

men. Women were also twice as likely to say it had a negative effect on their financial well-being.

About 40% of companies fail to offer extended parental leave. Most notably, the average length of paid maternity leave has remained at 10 weeks

since 2016, compared with an increase in paternity leave to seven weeks from four weeks over that same period, and to the 20 weeks that women, on average, receive in Europe.

McKinsey recommended that, because parental leave is critically important to many employees, companies would be well served to provide it more generously. ✨

“IF [COMPANIES] WERE BETTER ABLE TO HIRE AND PROMOTE TO FIRST-LEVEL MANAGER, WE COULD ADD 1 MILLION MORE WOMEN TO CORPORATE MANAGEMENT IN THE NEXT FIVE YEARS.”

– Jess Huang, partner, McKinsey & Company

Developing Women’s Career Experience, a nomination-based, 14-month program to help prepare emerging women leaders for more complex leadership roles and broader experiences. The program not only trains women in key leadership skills such as business acumen and strategy, but also increases the sense of urgency to promote women. The effort has paid off, with many participants taking on expanded roles and responsibilities within six months of completing the program.

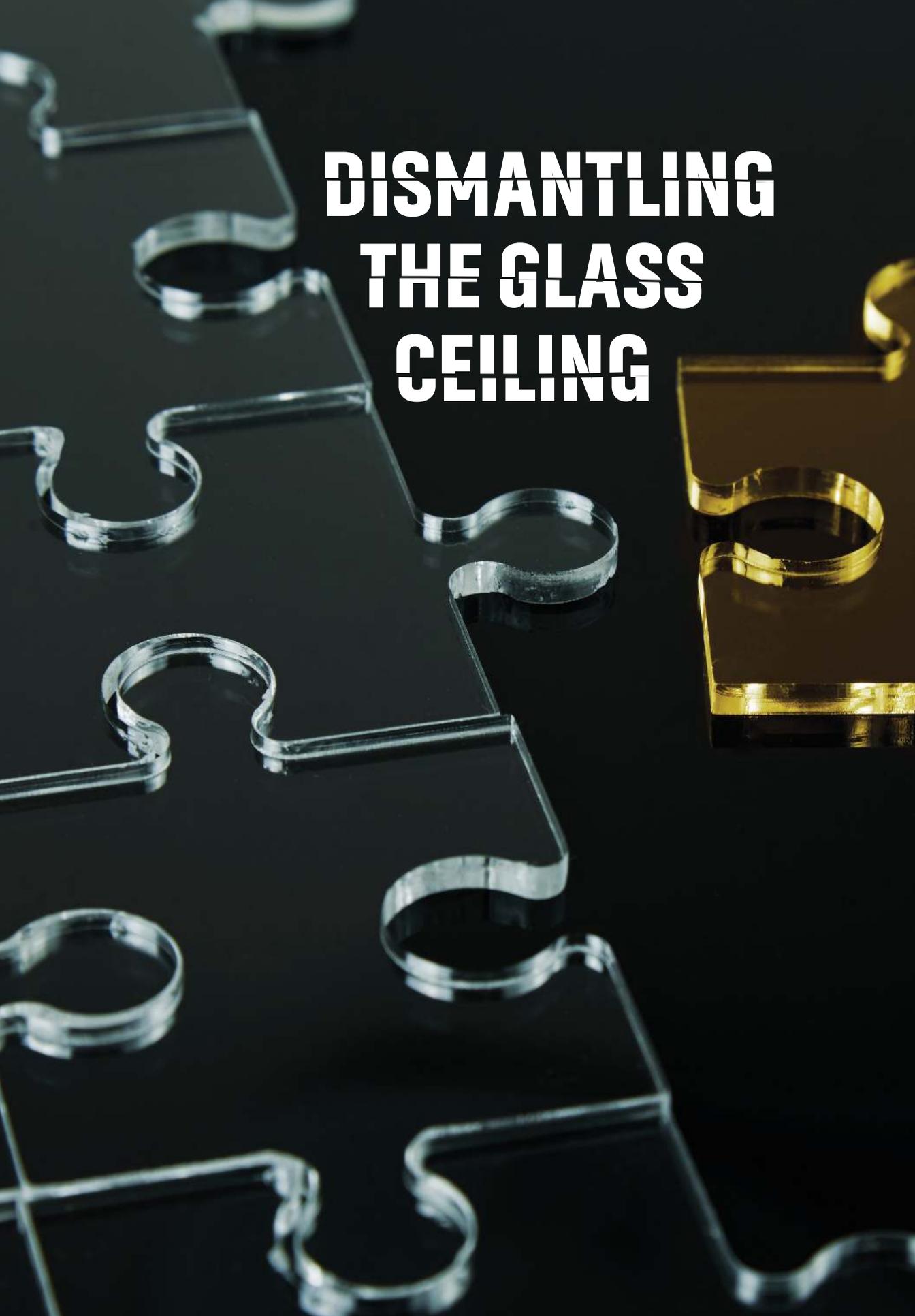
“We’ve found it’s not just about developing people to be experts — but to help them be able to lead,” Dr. Pace said. “Leading is different from managing as an expert. Within our program, as a leader, there may be things you’re leading that you don’t have deep expertise in. But you have to be able to excite people to aspire to meet those goals.

“How do you now lead when you’re no longer in the expert role? What does that require?” Dr. Pace said. “It’s really around knowing how to develop the right leadership skills so you’re motivating, inspiring, and coaching.”

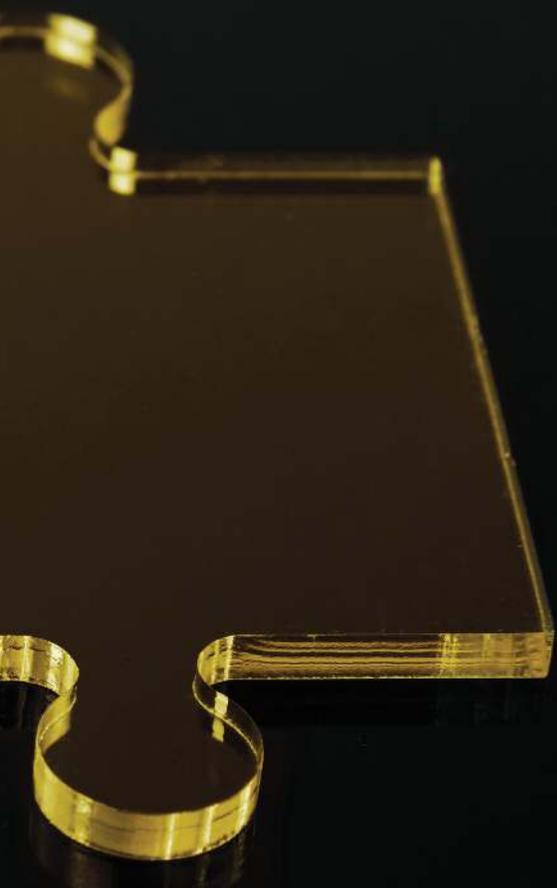
Women’s Business Networks (WBNs), where MetLife employees focus on fostering a global community where all women thrive through career development and engagement activities. Through its WBNs, MetLife runs “Lean In Circles” — a program that brings small groups of employees together for monthly peer support and mentorship.

MetLife also uses external recruiters to identify diverse talent, ensures that job requirements are gender neutral, and trains recruiters on selection process issues that could impede diverse hiring.

More than half of MetLife’s managers and entry-level workers are now women. MetLife recently launched *Aspire to Lead*, a three-day program aimed at helping women who are new to management roles build skills in leadership and relating to others so they’ll be more successful.



DISMANTLING THE GLASS CEILING



A variety of factors contribute to the persistence of the glass ceiling. Fresh insights — from identifying and addressing gender sidelining to re-examining the role of recruitment and hiring practices — offer strategies that can lead to solutions.

By Sandra Guy, SWE Contributor

ATAVAN

We might call it unconscious bias' evil cousin. It's dubbed "gender sidelining." Research shows this type of insidious discriminatory treatment involves subtle actions with no legal consequences. Examples include male bosses who minimize women's accomplishments, interrupt when women talk, create barriers to opportunities and mentorships, omit women from high-impact project teams, and subject women to harsher scrutiny than their male colleagues.

Indeed, gender sidelining encompasses "the universe of subtle ways that obstacles and hindrances might impact a woman's career," said Jessica Fink, J.D., the Clara Shortridge Foltz Professor of Law at California Western School of Law, who used the term in her Stanford Law and Policy Review article, "Gender Sidelining and the Problem of Unactionable Discrimination" (2018).

"It's all the nonlegally actionable stuff that can get in the way of a woman's advancement — some might be intentional obstacles, some may be unintentional," said Fink, who earned her undergraduate degree in political science from the University of Michigan at Ann Arbor and her law degree from Harvard. "Once you start looking for it [gender sidelining/downplaying women's accomplishments], it's everywhere in virtually every working environment," she said.

Fink said she initially downplayed the idea that academic research could be a platform for her interest in the media and/or others downplaying women's achievements. She had noticed that several newspapers' front-page stories about Hillary Clinton's nomination as the first female major-party candidate for president were accompanied by photos of Bill Clinton, as well as the controversy surrounding media coverage of U.S. Olympic swimmer Katie Ledecky's new world record and gold-medal accomplishments in the 2016 Olympics. In one newspaper, Ledecky's wins were printed as a subheadline beneath a primary, large headline about Michael Phelps' three-way tie for a silver medal.

But a colleague suggested Fink’s law school faculty peers talk about the issue at an informal “cocktail-napkin discussion.” Fink felt encouraged when her peers said these examples of sidelining might correspond with how women are treated in other types of working environments. In the sciences, for example, female scientists not only have sometimes failed to receive proper credit for their work, but also have been held to a different — often higher — standard than their male peers. In the arts, female artists remain underrepresented in terms of having their work showcased by major museums, while women in the entertainment industry face different expectations than men in terms of appearance and career longevity.

And, in the corporate world, female workers often have more-limited access to leaders and opportunities

for growth; are frequently evaluated differently than their male peers; and report finding their ideas being overlooked, ignored, or usurped. In fact, a lingo has even sprouted up to

identify the problem, with phrases such as women being “man-terrupted” while they’re talking at a meeting, and having an idea “bro-priated” (“bro” being shorthand for men).

WHAT CAN BE DONE?

“We need to really take steps to strengthen the relationship between men and women at work,” said Fink, who litigated sexual harassment and wage-and-hour discrimination at a major law firm in Chicago prior to her academic career. “I think simply recognizing this is a problem can go a really long way,” Fink said. “It’s not going to be a magic bullet, but it’s an important first step. After all, decision-makers know they’ll have to justify their decisions, and C-suite management is comprised primarily of white men.”

Women can fight back against having their ideas sidelined if they and their female colleagues agree

that, if one of the women mentions a good idea, the rest of the women will repeat it and give credit in the meeting. Fink said it’s important to realize that evil intent is rarely the problem.

Nor does Fink believe the workplace slights should be legally actionable. “It’s far too subtle of a problem,” she said. “The law is not a precise tool to deal with issues like this. A lot of these scenarios are far too nuanced to fall into that bucket. Civil rights law — specifically, Title VII, which prevents gender discrimination — wasn’t intended to address every snub you can imagine.”

Another step would be to ensure that women are hired for and promoted to leadership positions, both in the workplace and in academia, Fink said. She noted that “placing women into positions of authority counters entrenched stereotypes regard-

ing whether and how female employees can lead.”

This countering of stereotypes can start even before women hit the workforce. “Research shows that students

who had the greatest number of female professors during their first year of college showed the greatest decrease in implicit gender bias,” she said.

But there’s a hurdle. “The pipeline [to C-suite positions] isn’t rich with women,” she said. “A lot of employers are scared to tackle those sorts of questions. If they don’t examine the questions, then they won’t have to deal with the answers, which they might not like.”

Brian Rubineau, Ph.D., assistant professor of organizational behavior at McGill University’s Desautels Faculty of Management in Montreal, said in an earlier interview that changing the internal workings of an organization is extremely difficult because solutions must be multilayered. “Trying to focus on one (issue) at a time results in very little progress,” said Dr. Rubineau, who has studied workplace inequality for 13 years.

Yet Fink said women can research and ask about

“THE PIPELINE [TO C-SUITE POSITIONS] ISN’T RICH WITH WOMEN. A LOT OF EMPLOYERS ARE SCARED TO TACKLE THOSE SORTS OF QUESTIONS. IF THEY DON’T EXAMINE THE QUESTIONS, THEN THEY WON’T HAVE TO DEAL WITH THE ANSWERS, WHICH THEY MIGHT NOT LIKE.”

— Jessica Fink, J.D., Clara Shortridge Foltz Professor of Law, California Western School of Law

a company's culture to get indications of whether gender sidelining might be a concern. "What are the chances of me having the greatest opportunities to succeed within this company? How many women are in the company? In leadership? What are the corporate policies? What's the family leave policy?" she said. "These policies and situations aren't directly related to sidelining, but they may tell you how much input women are having or how much issues of concern to women are being taken into account."

ASKING NEW AND DIFFERENT QUESTIONS

Glass ceiling patterns can also be the result of a company's recruitment and hiring processes.

Researchers Roberto M. Fernandez, Ph.D., and Santiago Campero, Ph.D. (2017), studied data of people who applied online for jobs at 441 small and medium-sized high-tech firms. At the time, Dr. Fernandez was Dr. Campero's doctoral supervisor at MIT. Dr. Campero earned his Ph.D. in management with a subspecialty in economic sociology, and also has a B.S. in engineering from Universidad Iberoamericana in Mexico City.

"Both of us had a longstanding interest in gender inequality," Dr. Campero said in a telephone interview. "The high-tech industry is an important source of job creation and where underrepresentation of women is a longstanding issue that has generated significant concern among academics, business leaders, and policymakers."

Dr. Fernandez is the William F. Pounds Professor in Management and a professor of organization studies at the MIT Sloan School of Management. He also serves as the co-director of the economic sociology Ph.D. program. Dr. Campero is an assistant professor at the Centre for Industrial Relations and Human Resources at the University of Toronto.

In contrast to past studies of relatively mature, single-firm hierarchies, Drs. Fernandez and Campero studied the sample of small and medium-sized high-tech firms because they have relatively flat organizational structures. They focused on examining the sources of the glass ceiling, or the tendency for women to become increasingly scarce at higher organizational levels, in the high-tech sector. Their sample of small and medium-sized firms provided a conservative test for studying the glass ceiling, the two authors said.



Jessica Fink, J.D.



Santiago Campero, Ph.D.

They focused on the hiring process, given that research on the glass ceiling has focused almost exclusively on internal promotions. Though the study found evidence that the glass ceiling is produced by both internal and external hiring processes, it found that a company's recruitment and outreach policies were the real key to obtaining greater gender parity.

"Much of the research that's tried to explain the glass ceiling has focused on internal promotion barriers and the fact that women might face barriers in promotions," Dr. Campero said.

Yet Drs. Fernandez and Campero sought to ask a new and different question: Could the glass ceiling also come from external hiring?

"We show that, if you look at who gets hired in these companies at different levels, you get this same glass ceiling pattern — women are less and less prevalent as you move up the hierarchy," Dr. Campero said. "Even though internal promotional barriers may be one factor, external hiring can also lead to the same pattern. That's important because, potentially, the people making external hiring decisions or the processes through which they're made are different than internal promotions. It's a different place to look."

GENDER-EQUITABLE CANDIDATE POOLS

The findings suggest that outreach efforts aimed at encouraging female candidates for senior positions should be a high priority in addressing the glass ceiling. Though the research didn't offer specific suggestions for outreach, Dr. Campero said it could involve companies better communicating with women candidates and networking with

women’s professional groups and women’s meetings and organizations.

The study revealed that policies targeting gender biases in internal promotion would be insufficient in addressing the problem, given the influence of external recruitment processes in filling many high-level positions.

In contrast with policies aimed at ameliorating promotion disparities — for example, changing supervisors’ gender-biased internal assessment processes — external recruitment and hiring processes are often controlled by human resources professionals charged with reaching beyond the organizational boundary.

At a minimum, the authors said their findings suggest that policy efforts specifically aimed at gender disparities in external recruitment are needed to make progress in overcoming

the glass ceiling. Moreover, the researchers’ data analyses and “what if” simulations of the processes at work in the external hiring interface provided further guidance for designing policies to address the glass ceiling.

“Recruitment policies aimed at producing more gender-equitable candidate pools for jobs at higher levels of the hierarchy are likely to pay the biggest dividends in ameliorating the glass ceiling,” they said. They realized early on that a major reason for a lack of understanding of the glass ceiling had to do with obtaining adequate data.

“In our analyses of hiring processes at these firms, we tried to account for how much of the glass ceiling is coming from disparities in screening — in who the firms invite for interviews or who they give job offers to, versus how much comes from the composition of their initial applicant pools,” Dr. Campero said.

“Most of the disparity is coming from the increasing scarcity of women candidates at higher organizational levels,” he said. “It suggests that,

in order to remediate the glass ceiling, one of the most impactful things firms can do is to try to put in place policies that will increase the number of women candidates.”

“You tend to see a dropoff in the share of female applicants for the most senior positions, which makes it all the more important to have outreach efforts,” Dr. Campero said, adding that he was surprised to see the influence that the initial composition of the applicant pools had on producing the glass ceiling.

“I think a lot of the conversation around the glass ceiling often focuses on implicit bias — and that

may play a role in some of these hiring decisions,” he said. “We do find, especially for roles in engineering or IT, disparities in screening that could potentially be the result of implicit bias.

We’re not say-

ing that may not be important. Even though the conversation is very focused just on this issue of implicit bias and how it may affect hiring decisions, the initial composition of the applicant pool and the extent to which women may not be applying to some of these positions is an even more influential lever.”

To separate the internal and external barriers to women’s achievement within the organizational hierarchy, the researchers had to properly identify the pool of both internal and external candidates who were competing for job openings across levels of the organization.

For each position they studied, they obtained information on who was competing for the job, who made it through each stage of the process, and who was eventually hired. With this information, they were able to assess the initial gender composition of applicant pools, and how this gender composition changed across various stages of the hiring process. They then conducted a series of “what if” simulations.

“IT IS WORTH CONSIDERING WHAT WOULD HAPPEN IF THE OVERALL SUPPLY OF FEMALE CANDIDATES WERE TO INCREASE, FOR EXAMPLE, AS A RESULT OF OUTREACH POLICIES DESIGNED TO ATTRACT MORE WOMEN TO THE HIGH-TECH SECTOR OVERALL, OR TO ENGINEERING JOBS IN PARTICULAR.”

– Santiago Campero, Ph.D., assistant professor, Centre for Industrial Relations and Human Resources, University of Toronto

On the demand-side, they examined the impact of men and women advancing through the hiring process at equal rates (i.e., unbiased screening). In this scenario, the pattern (i.e., fewer women at higher levels) is alleviated, but only slightly. To assess the influence of supply-side factors, they examined the impact of attributing to applicant pools at each level the same proportion of females as were present in the firm's overall pool of job candidates.

"We said, 'Instead of having the pattern where the applicant pool has fewer women as you go up the hierarchy, let's assume you have the same number of females overall and that they are distributed at the same percentage at each level — eliminating the downward sloping pattern of female candidates becoming scarcer at higher levels while keeping the total number of women candidates constant,'" Dr. Campero said.

When they considered the impact of distributing women candidates across levels in equal proportions, they found that such a change would have a significant impact on the glass ceiling.

In essence, this suggests that the fact that women candidates tend to be concentrated in lower-level vacancies is a large driver of the glass ceiling.

It's important to note that the study encompassed a range of functions and roles, but gave special focus to IT/engineering jobs, given the particularly salient concerns about gender bias in these roles. IT/engineering jobs were the one place where gender disparities in screening were the most disadvantageous to women, consistent with the idea that women face larger barriers in accessing these roles. But, even in IT/engineering, achieving a greater female representation among job candidates for senior-level positions emerged as the biggest lever to address the glass ceiling, Dr. Campero said.

TOWARD EFFECTIVE SOLUTIONS

Prior research has shown that multiple factors contribute to the lack of female candidates to jobs in engineering. These can include, for example, the impact of cultural associations of engineering with masculinity, which can discourage women from forming high aspirations in these fields.

The findings suggested that efforts aimed at increasing the supply of female candidates — both

by individual firms and industrywide — may pay greater dividends than would efforts to address gender bias in screening.

"It is worth considering what would happen if the overall supply of female candidates were to increase, for example, as a result of outreach policies designed to attract more women to the high-tech sector overall, or to engineering jobs in particular," Dr. Campero said.

That's especially important for newer, rapidly growing high-tech organizations. The study was the first to document a glass ceiling being formed through the early influx of new personnel. "These small firms might not yet have large pools of internal candidates to stoke an internal glass ceiling pattern, but their rapid growth generates many vacancies and promotion opportunities for candidates who are likely to be external," the research said.

"That these companies were resorting to large-scale recruiting over the internet suggests a desire to expand their potential talent pool beyond their current workforce and direct network ties," the research found.

"For young, rapidly growing high-tech firms, focusing on external recruitment and hiring processes is likely to be the most effective way of tackling the glass ceiling. In this respect, the data analyses and 'what if' simulations provide further guidance for designing policy efforts to address the glass ceiling."

"Showing the supply side is so impactful," Dr. Campero said. "It points to the importance of investigating what can be done to encourage women to seek these higher-level positions."

"Although there are likely multiple factors that contribute to the application patterns we uncovered, making progress in elucidating them should be a high priority for those trying to address the glass ceiling in the high-tech sector." ✨

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Women in Engineering Talent Pulse Report

Employees want to feel valued. They want recognition of their contributions. But more than that, they want to feel that they have a future in their organizations.

By Roberta Rincon, Ph.D., SWE Senior Manager of Research

In 2019, the Society of Women Engineers conducted a study¹ to understand how women engineers feel about their workplaces. What do women engineers seek in an employer? What factors do they look for when determining whether to stay or leave a company? As one respondent said: *“I just don’t want to feel like a cog in a machine. I want to work somewhere where I feel valued personally and am encouraged (and given opportunities) to grow beyond my current work assignment.”*²

Companies are interested in retaining diverse engineers and technologists, and the results from this survey point to areas on which employers can focus to improve women engineers’ experiences in their organizations.

SALARY. Engineering is known for being a well-compensated profession, and the responses from our survey support this. Most of the women in our study indicated that they were satisfied with their salaries. “I really like working where I am at. I hope to grow personally and professionally within this company and hopefully my salary would grow as well,” one respondent noted.

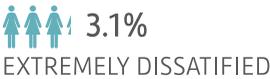
LOYALTY. More than 70% of women respondents said that they planned to stay with their current employer for at least two more years. When asked what factors were influencing their decision to stay, almost half listed considerations related to career advancement.

Employees want their work to be valued and recognized through promotions, salary raises, and other professional recognitions. They seek employ-

STUDY SAMPLE SIZE: 2,971 ENGINEERS



HOW SATISFIED ARE YOU WITH YOUR CURRENT SALARY?



ers who care about their growth and offer ways for them to reach their individual career goals while fulfilling the company’s mission. This sentiment was best captured in the following quote:

“I want a company that believes in me, and empowers me to achieve great things by providing me the support, training and mentorship that I need.”

WHAT WOMEN VALUE AND SEEK. For a variety of reasons, women’s advancement into leadership positions has been slow. Many women are frustrated by the barriers they face on the career ladder, and this is especially the case for women in male-dominated STEM fields. A recent report from McKinsey & Company found that certain STEM industries, including oil and gas, engineering and construction, and energy sectors, are particularly underrepresented at every level of the corporate ladder.³ The study indicates that these sectors lose a disproportionate number of women early in the pipeline, finding that women are less likely to be promoted from entry level to managerial level than women in other industries.

While women engineers seek employers who believe in them and are willing to invest in their professional development, work/life balance benefits also ranked highly among those surveyed. Understandably, desired benefits change as women

grow older, and this was reflected in the survey responses. One respondent noted:

“Work and life balance is important in order to be able to stay highly productive and healthy for long-term ... Being able to learn and grow is also important to allow employees to pursue their passions within their career and feel supported in their development and continuous learning.”

Childcare was not a benefit that was listed as “most important” by many of the women engineers in the study, but a number of women commented on this issue in the open-ended question:

“Childcare was rated lower on my list because of my age. When I was in my 30s and 40s, it would have been on top.”

“With local day care facilities having wait lists 2+ years long, having child care on site would be a HUGE benefit and would have a huge impact on working women being able to continue working and have a family.”

“It’s not flexible hours or childcare or healthcare. It’s ‘and.’... Instead of asking [employees] to choose if they value their children or their health more, ask them what keeps them up at night or what makes it hard to finish a project at work. Start a conversation.”

WHICH OF THESE FACTORS IS MOST INFLUENCING YOUR DECISION TO STAY?

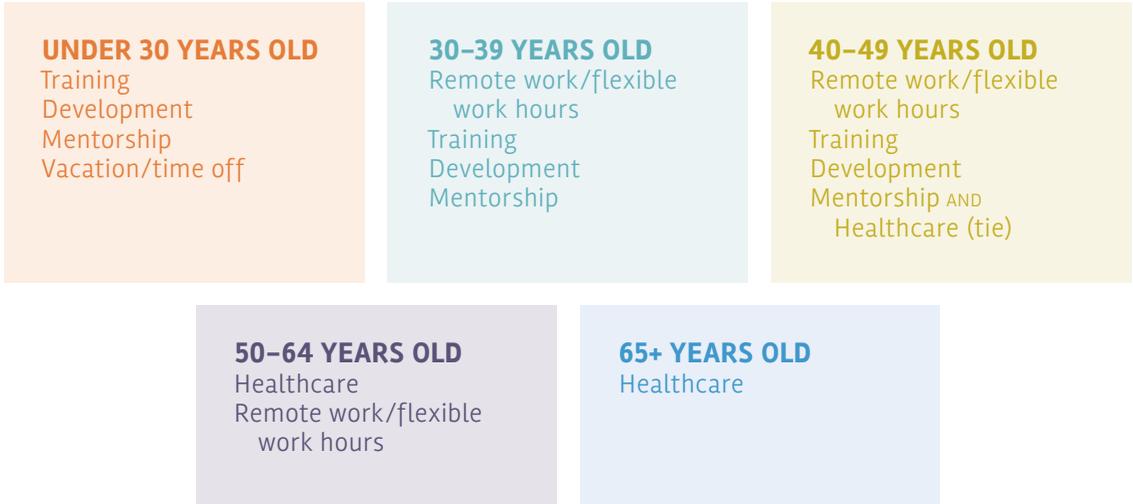


It is clear to see that one size does not fit all when it comes to meeting the needs of women in the workforce. Women engineers seek balance, and employees in today’s workplace have options. If they are dissatisfied with their current employer, they can look for an organization that offers them the flexibility, professional growth, and other benefits they seek. So, what do women engineers seek when evaluating a career move? Consistent with other responses, one woman stated her priorities:

“I just switched jobs, leaving a place that better aligned with my values so I could have greater opportunities and growth, with the added benefit of a higher salary.”

Many companies have realized that they must do more than create policies that do little to change behaviors, or provide cool workspaces with the expectation that employees will make the office their second home. To change a culture, employers must show that they value their employees by listening to what they need to be their best at their current job, with an eye to supporting their growth. Career-advancement opportunities have a direct effect on our ability to retain a diverse STEM workforce. Companies that recognize the value of their employees will address the issues that are hindering the advancement of women and other diverse groups in their organizations. ✨

OF THE FOLLOWING BENEFITS, WHICH IS MOST IMPORTANT TO YOU?



WHICH OF THESE FACTORS ARE MOST IMPORTANT WHEN CHOOSING A NEW EMPLOYER?



To read the 2019 Women in Engineering Talent Pulse Report, visit <https://research.swe.org/>. To learn how your organization can support women engineers in the workforce, check out SWE’s diversity & inclusion products at <https://swe.org/learning/dipproducts/>.

Endnotes

1. This study was conducted in collaboration with Dan Linstroth of People at Work.
2. The quotes throughout this article are from SWE’s 2019 Women in Engineering Talent Pulse Report, available for download at <https://research.swe.org/>.
3. Bellone, D., L. Kutob, J. Noël, and G. Siccardo (2019). *Empowering Talent: Women in Energy, Resources, and Infrastructure*. McKinsey & Company, Global Infrastructure Initiative.

The Role of Culture and Women's Persistence in Engineering: A Bi-Continent Roundtable Discussion

At a lively roundtable discussion in Berlin, STEM women in academia and industry from the United States and Europe covered a number of relevant topics, ranging from the biggest challenges facing women to effective policies and programs, to the role of male allies.

By Anne Perusek, SWE Director of Editorial and Publications

OVERVIEW

In conjunction with the Society of Women Engineers' WE Local Europe conference in May 2019, members of SWE's research advisory committee met with colleagues based in Germany, Romania, and Austria. The highlights below are taken from hours of recorded dialogue, transcripts, and notes.

The discussion was divided into three main areas. Key takeaways are summarized in hopes of stimulating additional dialogues to inform best practices.

PARTICIPANTS

Roberta Rincon, Ph.D., SWE senior manager of research, facilitator

Carlotta M. Arthur, Ph.D., director, Clare Boothe Luce Program, The Henry Luce Foundation

Caterina Cocchi, Ph.D., junior professor, Humboldt-Universität zu Berlin

Diane Foley, senior director, information technology, Raytheon Co.

Karen J. Horton, P.E., professor, mechanical engineering technology, The University of Maine

Alina Maria Negru, general manager, Emerson Cluj, Romania

Charlotte Reinisch, deputy main women's representative, Technical University of Berlin

Andresse St. Rose, Ed.D., senior director, research, evaluation, and policy, Center for Collaborative Education

Rishelle Wimmer, senior lecturer, information technology and systems management, Salzburg University of Applied Sciences

Peter Finn, SWE deputy executive director

Anne Perusek, SWE director of editorial and publications

QUESTION ONE: FROM YOUR PERSPECTIVE, WHAT DO YOU SEE AS THE BIGGEST CHALLENGE TO RETAINING WOMEN IN STEM?

The first discussion covered personal experiences, observations, anecdotes, and research data. While we can attribute many factors to the underrepresentation of women in engineering and the STEM professions overall, the underlying themes point to culture. As one participant noted: "It really boils down to culture and the way that translates into policies ... and certain policies can hinder women's career advancement."

In short, while the biggest challenge to retaining women in STEM is culture, this is expressed in a multitude of ways, including behaviors and expectations ranging from societal norms concerning gender roles, child raising, and educational practices, to workplace practices and policies.

In the United States, the lack of guaranteed paid or unpaid family leave has been an ongoing policy debate. It was quite a contrast for the U.S.-based participants to learn how family leave plays out in some European countries, where it can last two to three years.

“I liked the work, but it was a hostile workplace in part because the expectation was that everyone would behave like a man. And there would be meetings in the men’s room. They had meetings on the golf course. They’d have meetings at the bar. And those places were places where I was not necessarily even able to be physically in that space. From a woman engineer’s perspective, those situations would be impediments to her ability to reach the next level repeatedly... over and over again.”

— Carlotta M. Arthur

“One of the big messages young women often get is that success in STEM requires single-minded devotion. If you want to get a bachelor’s degree, get a Ph.D., pursue a career, it requires a single-minded devotion — that very outdated male-model. ... So, they begin to think, ‘Well, I could be successful in other areas and still have my other interests or goals,’ because, again, what we see based on the research in the States is that women who are successful in math and science usually have other interests, and they’re successful, generally.”

— Andresse St. Rose

CHALLENGES

- Maternity leave can be two or three years in some European countries, during which the technology changes. If a woman has another child, she may be out of the workforce from four to six years, after which many women don’t return. Conversely, in the United States, maternity leave is frequently no more than six weeks, creating a different situation that also may result in women not returning.
- Career instability and the male-oriented culture in German academic life are drawbacks for women. The lack of a tenure track beyond a very small percentage makes it difficult for women to understand or plan an academic career path, plus doing so requires mobility and a partner who can also be mobile.
- Young women are frequently discouraged by family from studying STEM subjects and are cautioned they will have difficulty finding a husband if they do so. Even without the concern that finding a partner will be difficult, STEM is not considered a suitable profession for women, particularly in families who do not have members in STEM professions.
- Negative messaging around being a scientist or engineer, including the misperceived notion that doing so requires “single-minded devotion,” makes these professions unappealing.
- Many IT companies and companies with large IT staff look to the “bro culture” of Silicon Valley as a model. This dissuades many women, who question why they should subject themselves to fighting it every day when there are other jobs that won’t require that energy.
- Women’s career advancement has been hurt by a lack of consistency and transparency in performance evaluations.
- Not enough women are in leadership, which is a function of the evaluation process. Men evaluate other men and will promote based on trust or potential, while women are not promoted on these criteria. What is seen as “leadership” tends to be male traits.
- Some well-meaning policies are more beneficial to men than for women. For example, men in academia may take the parental leave and then use that time to write and publish research rather than care for the newborn.
- Even in organizations that do not offer mentoring programs, men are still being mentored/sponsored, and women are being left behind.
- In industry, holding business meetings in places women can’t or don’t frequent puts women at a disadvantage.

ACTIONABLE IDEAS

- Companies and institutions develop policies that make returning after an absence more feasible and appealing. Pilot programs to help women return from maternity leave or other absences; the creation of more “off ramping” and “on ramping” opportunities.
- Develop policies that support women in academia through clear career pathways.
- Companies demonstrate to women that there is a career path for them in engineering. This includes outreach efforts and recruiting students early.
- Counter the messaging that portrays STEM careers as all or nothing, single minded, or giving up a more “typical” or “normal” life.

QUESTION TWO: CAN YOU CITE SOME EXAMPLES OF POLICY AND PROGRAM INTERVENTIONS THAT HAVE BEEN EFFECTIVE IN HELPING TO RETAIN WOMEN IN STEM? THIS COULD BE SOMETHING THAT YOUR INSTITUTION IS DOING OR HAS DONE, OR YOU'VE SEEN OR HEARD ABOUT FROM OTHER ORGANIZATIONS.

Establishing the tone and much of the content of the discussion, the initial response to this question was: “Every woman needs mentoring, and programs that provide support for a variety of topics that women care about.” From that point, various aspects of formal and informal mentoring programs — key interventions that bring positive results — were considered. The merits of male versus female mentors, mentoring teams, and the different but important role of sponsors were explored.

Closely related to mentoring are networks, which is one of the reasons a mentoring team can be helpful in providing access to different networks, as well as strategic networking. Further, sponsors can recommend women for awards and to serve on panels, extending the notion of networking.

The importance of clear policies; of bringing awareness to unconscious bias in the moment it occurs; and bringing more women into leadership roles were also discussed; and the necessity of

having a vehicle to combat men’s belief that there are no qualified female applicants for a position was noted.

Finally, it was pointed out that effective practices and policy interventions around the key milestones of hiring, evaluation, and promotion can help mitigate bias in workplace processes but do not necessarily change the underlying culture.

“At every stage, especially in STEM disciplines, having successful female students who motivate and mentor younger students, or female pupils, is really important because they show themselves as models. On higher levels, programs providing women in STEM support for any topic — any sensitive topic, starting from time management to solving conflicts, or how to manage a group, big or small.”
– Caterina Cocchi

“The places where I have seen people move is when we discussed gender differences, and then actually had shared examples. At work, I speak pretty provocatively about this topic. About six to eight months after one instance, a gentleman who was there said to me, ‘You know that thing you said, where a woman speaks and then a man says the same thing a few minutes later and it’s a great idea? It happens all the time.’ All of a sudden, he could see it. I opened the aperture so he could say, ‘Maybe there is something to this ...’ But I was in a unique position. I was in a more senior role, and I could say what I wanted to say.”
– Diane Foley

“Some German universities established active recruiting offices. Their focus lies on identifying female candidates who could fit the job. Often, search committees argue that they cannot find suitable female candidates, so female candidates addressed by universities’ recruiting offices can sometimes be a game-changer.”
– Charlotte Reinisch

“What has really helped retain more women in STEM was creating this career path showing that they can grow in different ways such as leadership, and also through mentoring programs...We have very strong women who are specialists, and showing them that they can become really good specialists and putting them in contact with other specialists has really helped reduce employee turnover. We also started up ERGs [employee resource groups] so people feel that they belong to communities of like-minded people such as the Women in STEM group, where they can develop themselves, building on common interests and passions.” – Alina Maria Negru

POSITIVE INTERVENTIONS

- Having access to both male and female mentors — a male mentor can provide a woman access and insight into the buddy/bro culture, and how to effectively navigate it. There are some issues a male mentor cannot understand, however, and a female mentor provides a different perspective.
- Strategic networking with mentors who can provide helpful information, such as which events to attend, can help with career advancement.
- Hiring committees that are not all male or all white; with key competencies required for the position clearly stated, with a defined rubric. When there are several finalists, return to the rubric and be rigorous in this process.
- Bringing more women into leadership roles increases the likelihood that different perspectives will become part of the conversation and the decision-making process regarding programs and policies.
- An initiative in Berlin that provided junior faculty from three different universities an opportunity to participate in a mentoring program; one of the participants described how she chose a male mentor in her discipline, and it turned out to be a very positive experience.

- Another university created a council of various administrators who come together to discuss campus culture and issues affecting women, and to develop methods to solve problems. These solutions are shared across the campus, so there are many people who can step in with advice or guidance when an issue arises.
- Bringing awareness to unconscious biases in the moment, when they occur. By pointing out unconscious bias, others become aware of the problem, and they are more likely to notice it when it occurs again. Acknowledge that it is hard to point bias out in the moment, especially if you are not in a position of authority.

QUESTION THREE: SOME RESEARCHERS THEORIZE THAT MEN MAY EXPERIENCE A TYPE OF “PIVOT POINT” THAT LEADS TO GREATER AWARENESS OF GENDER INEQUITIES. HAVING EXPERIENCED FEELINGS OF MARGINALIZATION OR OTHERNESS THEMSELVES, OR KNOWING SOMEONE CLOSE WHO HAS EXPERIENCED INEQUITIES, SUCH AS A DAUGHTER OR A WIFE, CAN RESULT IN AWARENESS AND SUPPORT OF GENDER EQUITY POLICIES. WHAT ARE YOUR THOUGHTS ON THIS THEORY?

Discussion began with one researcher’s observation that in her experience, men in STEM frequently mention their personal connections (wives, daughters) as the reason they support gender equity efforts. “That’s great, but it’s not enough ... We cannot wait for every man to have a daughter who aspires to a STEM field,” she said. Additionally, what more are they doing to help women in STEM, beyond just their own daughters?

Others wondered whether these men would care about equity if they did not have the personal connection. Further, why do men care now, considering that men have had wives, daughters, and granddaughters in the past who were interested in STEM? Is it the timing — because now it’s “hip” to be a male feminist? Yet another view was offered: That in the past, men did not want their daughters to be discriminated against, either, because they took it personally.

There was no consensus on whether men’s views of women evolve through changing habits, through

motivation, or the influence of larger societal changes. In other words, which of these contribute to men becoming more accepting of, even supporting, women in STEM?

Noting that there is frequently a cost to men who choose to support gender equity — as there is to anyone who is fighting for equity for those in the minority — how do we ensure that the benefit of doing so outweighs the cost?

“Men have had daughters and they've had granddaughters. They've had wives. They've known how hard it was for them, and it hasn't changed. So, I feel like it's more hip to be a feminist — or a male feminist right now — because of social media and social outcry. But I don't think that just having daughters or granddaughters makes that much difference. Maybe it helps those men to start thinking about the situation and have empathy, but I feel like it hasn't helped for a very long time. So why should it help now?”
 – Rishelle Wimmer

“To the point of having some kind of a transformational moment, I talk to my students not only about the technical part of my internship, which was a hostile work environment long before case law had been established to address it. I tell them point-blank, ‘This is exactly why I couldn't talk to students about my experience for 30 years.’ And they sit there, and they're silent. And they look at me. And one of them will eventually go, ‘That's horrible.’ And so, there are ways that even individuals who are not the daughters and the granddaughters — I think individuals have some ability to move at least those people with whom they come in contact.”
 – Karen Horton

FOR CONSIDERATION

- Diversity can function as a “game changer” and has led to improvements in Germany, particularly in academia, over the past 30 years. Some of this is attributed to the value international scientists and researchers have brought to German institutions.
- Having more women in STEM may make some men see, through experience, that there is benefit in diversity; but other men will need to see data that make the case for diversity in the workplace.
- Some people don't care about the data. But if the majority listen, or even the “right person” does, it can influence change.
- Addressing explicit bias will require a different strategy than just exposure to outstanding women scientists or engineers.
- Everyone can serve as a storyteller to help change people's minds about the need to address gender equity in STEM.
- Is the MeToo movement making a real difference? Or is it fleeting?
- MeToo conversations are not really happening in most corporate settings because of the focus on sexual assault or harassment rather than unconscious bias.
- Sometimes you have to make the business case for change because the moral argument doesn't work for everyone.
- It's bad enough when men are not allies, but it's worse when women who have made it up the ranks and through the struggles begin “acting like men.”
- Women alone can't end gender bias; men who are allies have to talk to other men, though there is a risk to speaking out; and other men need to be willing to listen. ✨

The Community College Pathway: A Closer Look

Among the various pathways engineers pursue toward completing their degrees, the community college transfer is gaining attention, due to its affordability and as a vehicle to broaden the participation of underrepresented groups.

By Roberta Rincon, Ph.D., SWE Senior Manager of Research

College costs continue to rise. Many students see community college as a way to start earning their degrees while avoiding significant debt. Almost 40% of undergraduates in the United States attend a public two-year college (National Center for Education Statistics, 2018). Among recent STEM baccalaureate degree earners, more than half indicated having done some community college coursework (National Science Foundation, 2020). In 2017, 43% of Hispanic and black undergraduate students and 36% of undergraduate women were enrolled in a community college (U.S. Department of Education, 2018).

Research indicates that more than 80% of first-time community college students intend to transfer to a university to complete their baccalaureate degrees, but only 33% successfully do so (Horn and Skomsvold, 2011; Jenkins and Fink, 2016). However, more than 65% of students who transfer in engineering do successfully complete an engineering baccalaureate degree (Burke and Mattis, 2007). If we can better support students before and through transfer, there is a real opportunity to significantly increase the diversity of engineering graduates.

A REFRESH ON SWE'S PRIOR RESEARCH

In 2017, SWE released its first research report on community college transfers in engineering and computer science (ECS). We wanted to increase our understanding of the issues that women and other underrepresented students face on the community college path toward an ECS bachelor's degree. To start, we launched an exploratory study of existing education data in Texas, looking at the rates of degree completion of more than 350,000 transfer

students from the 2002-03 academic year through the 2011-12 academic year.

By analyzing enrollment data, major selection, and student demographics from 60 two-year colleges and 25 four-year universities, we were able to gain a better understanding of the success of first-time-in-college degree-seeking students who began their ECS studies at two-year colleges, broken down by gender and race.

Three findings in particular were compelling. First, in any given year, tens of thousands of students in Texas transfer from two-year to four-year institutions. And, while more women than men transfer overall, less than 2% of female transfer students major in ECS compared with 11% of male transfer students. In head count, this equates to fewer than 4,000 women out of the more than 240,000 who transferred from two-year to four-year colleges and declared majors in ECS over the 10-year period of our study.

Second, women are switching out of ECS and earning non-ECS baccalaureate degrees at higher rates than men. Persistence and completion rates of ECS students were lowest among black and Hispanic students, regardless of gender. Across the 60 community colleges in Texas, half of them saw more than 38% of their female students and 28% of their male students switch out of ECS to non-ECS majors (1). Seven community colleges saw more than 50% of their female students switch out of ECS majors. This rate of major switching was not seen for men at any of the community colleges in our study.

Third, community college transfer students majoring in ECS have similar degree-completion rates

as students who begin their educations at four-year institutions (2). Completion rates among ECS transfer students in our study exceeded 60% for men and 50% for women for the 2005/06 cohort. This aligns with prior research on the success of transfer students in STEM.

THE CURRENT STUDY

The findings from our prior research left us with numerous questions. Given the success of students in completing ECS degrees after transfer, coupled with the diversity of the community college population and the high number of women choosing to begin their educations at two-year institutions, a greater understanding of why women on the transfer pathway in ECS are leaving these majors could help increase diversity in the engineering and computer science workforce. For SWE in particular, if we can better understand the obstacles and challenges these women are experiencing, we can develop better programs and services to support them along this pathway.

In partnership with the University of Washington’s Center for Evaluation and Research for STEM Equity, SWE developed a mixed-methods study of community college students in engineering and computer science. Building on our prior work, we sought to understand why women on the community college transfer pathway are choosing to leave ECS, and what can be done to increase women’s persistence.

Methodology. For this mixed-methods study, we developed a survey to capture information on students’ self-efficacy, motivations, and confidence in ECS(3). Survey data were collected from 414 students at three community colleges in Texas. Table 1 shows select demographic characteristics of survey respondents. The age range of respondents was between 18 and 58 years old, with a mean age of 25 years; 64% worked while going to school; 69% were full-time students; and 39% were the first in their family to attend college (first-generation students).

Scores were calculated and normalized, and the means were compared across gender and race/ethnicity groups using independent sample t-tests. Students also provided information on their educational histories, current areas of study, and intentions to pursue baccalaureate degrees

Table 1: Demographics of Survey Respondents

	FREQUENCY	PERCENT
Institution:		
School A	225	54.3%
School B	24	5.8%
School C	165	39.9%
Gender:		
Women	106	32.8%
Men	210	65.0%
Other	7	2.2%
Underrepresented minority (URM)*:		
Non-URM students	160	49.1%
URM students	157	48.2%
I prefer not to answer	9	2.8%

* For our study, URM includes American Indian or Alaska Native, Black or African American, Hispanic or Latino/a, and Native Hawaiian or Pacific Islander.

and careers in ECS. Chi-squared tests and logistic regression were performed to analyze intentions, motivation, inclusion, and efficacy measures.

To allow for a deeper understanding of women’s experiences on the transfer pathway, we conducted eight qualitative interviews with women recruited from the pool of survey respondents. Students who participated in the interviews were slightly older than survey participants and were more likely to be from racial/ethnic minority groups due to intentional recruitment efforts. Particular attention was made during the interviews to students’ reflections on the supports received and the barriers faced as they pursued their educational goals in ECS majors. We also interviewed four community college faculty members to gain their perspectives on the institutional supports and barriers that impact ECS students’ experiences at their colleges.

Among survey respondents, women were more likely than men to pursue or express interest in civil and biomedical engineering, or to be undecided about their engineering specializations. Men were more likely to express interest in mechanical or electrical engineering.

Results. The results from our study are categorized under major areas of focus. The reported results are from our survey data, with quotes

included to provide examples of experiences shared during the interviews. Interesting findings emerged from our research, but what surprised us most was how little difference we saw between demographic characteristics of gender and race/ethnicity on some of the measures.

Motivation, confidence, and self-efficacy. Our study suggests that men and women have similar motivations for studying ECS, with survey respondents indicating they were most motivated by intrinsic behavioral and psychological factors such as liking to build things and finding engineering fun and interesting. Students reported a high degree of motivation from a desire to do social good, or believing that technology and engineering skills contribute to the good of society, and women in our study were more inclined to express social good as motivation than men. There were no statistically significant differences by race/ethnicity or gender in financial, mentor, or parental motivations, and the latter two ranked lowest among motivational factors for pursuing an ECS degree.

However, we did see some associations between demographic characteristics and confidence in skills related to careers in ECS. In line with prior research, our survey findings show that men are more confident in their math and science skills than women (Figure 1). Research indicates that confidence rather than ability in math contributes to higher rates of women’s attrition from STEM, even when their performance is equal or superior to their male counterparts (Ellis, et al., 2016).

Students who were older tended to be more confident in professional and interpersonal skills. Age was also associated with greater confidence in solving open-ended problems.

Inclusion. Contrary to previous research on gender inequity in engineering, we observed no differences in sense of inclusion in engineering when we considered gender and race/ethnicity of survey respondents. Students reported that they relate to their classmates and that they have a lot in common with other students. However, women we interviewed commented that the lack of women in ECS classes and professions can sometimes make them doubt whether they belong in the field.

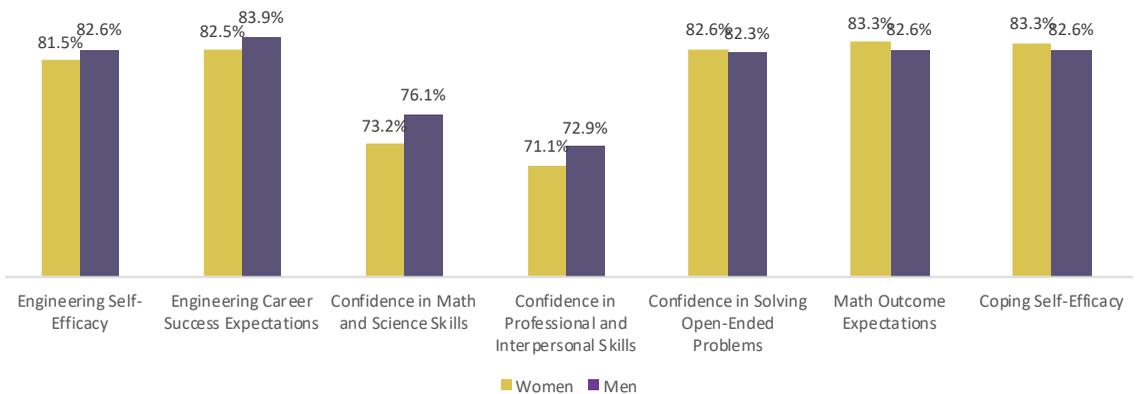
“I know that femininity and engineering [have] no correlation, but it does make me feel like, because I stand out, maybe I don’t belong.”

About half of interviewees mentioned the lack of women in engineering and the need for more women engineers.

Some interview respondents indicated that it was not so much their gender, race, or ethnicity that set them apart from their peers. Rather, they felt that their age was more of an issue to their sense of inclusion. Some respondents explained that their busy schedules prevented them from interacting much with their peers socially. However, overall there was a sense that the drive to complete an engineering degree was a quality shared by those we interviewed and their classmates.

Involvement in academic, extracurricular, and professional activities. Research shows that students

Figure 1: Confidence and Self-Efficacy by Gender



in STEM are more likely to persist when they engage in activities such as studying with others and involvement in academic clubs and organizations, particularly those from underrepresented groups in STEM (Chang et al., 2014). While the majority of survey respondents indicated that they participated in study groups, they were less involved in academic clubs and organizations. Outside of academic activities, 66% of women and 57% of men said they occasionally or frequently participated in extracurricular activities such as hobbies, civic or church organizations, campus publications, student government, or sports.

Several women we interviewed mentioned the difficulty of fitting extracurriculars into their busy schedules, but they saw them as beneficial academically, socially, and professionally. Those who were involved in clubs or activities outside of their coursework indicated they felt that these activities helped them develop leadership skills and build networks, and provided academic and social support as well.

Faculty members we spoke to also indicated that clubs at their colleges often struggled to maintain active membership and leadership.

“... there is a pretty good percentage of community college students who are here part-time, ... they are married, have families, have jobs, things of that sort. Getting them involved in college activities becomes a little bit more difficult because they have other things to do outside of classrooms and exams and their college life.”

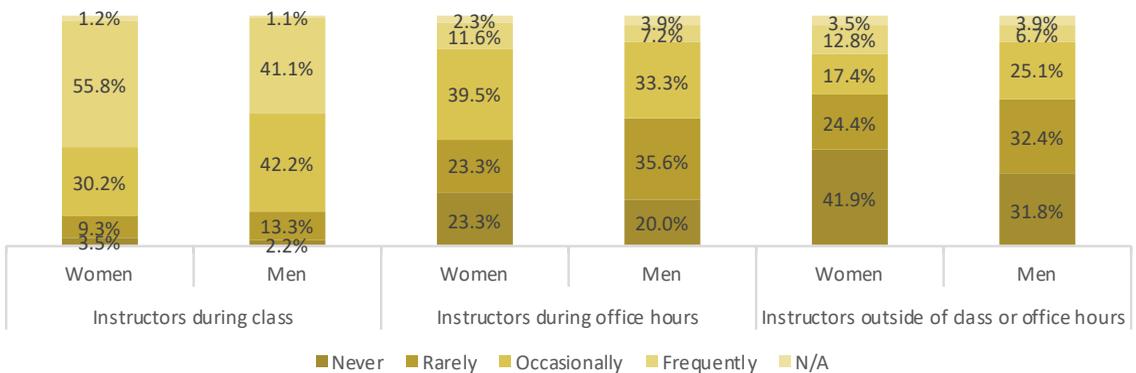
Many of the women we interviewed discussed the benefits of joining a professional engineering organization, though few of them had such an affiliation themselves. They noted that professional organizations can be a great source for information, networking, and career opportunities. However, mentorship was an important piece missing from several students’ experiences, and this could be a gap that such organizations can fill for the next generation of engineers.

Institutional factors influencing persistence in engineering and computer science. A number of institutional supports were mentioned as important factors in helping students as they progressed with their studies, including partnership programs, college centers, faculty support, and advising.

Partnership programs provide meaningful opportunities for those interested in transferring to complete their bachelor’s degrees (4). There is evidence that community college transfer retention is higher for students who have participated in partnership programs that offer coordinated academic advising, peer mentoring, and networking opportunities (Laugerman et al., 2013; Jain et al., 2011; McPhail, 2015).

During our interviews, students discussed specific centralized resources for STEM students within their colleges. For example, one student said that she relied on the mathematics, engineering, and science center on her campus for tutoring, computer access, and connecting with a community of peers. Other students relied on the veterans’

Figure 2: Frequency of Interactions with Engineering, Math or Science Instructors



office or international students' office to receive advising and get connected with other resources. Three-quarters of those we interviewed discussed utilizing tutoring resources on-campus.

We were also interested in the role that faculty and advisors played in women's experiences prior to transfer. Among our survey respondents, women were more likely to report interacting with faculty in class, but men were more likely to interact with faculty outside of class. Women were more likely than men to report frequently or occasionally interacting with instructors during office hours, and more likely to report never interacting with instructors outside of class or office hours (Figure 2).

When asked about their comfort level with asking questions during class, some students shared negative experiences that have made it less comfortable for them to do so. One student said that in response to a question she had asked, the instructor told her, "This is a piece of cake," in front of the whole class. While she indicated that such responses could make some of her peers less inclined to ask questions out of fear of "looking stupid," she also stated that she "would rather look stupid and get an A than not ask and get a C."

Quality academic advising can have a positive impact on student retention and satisfaction, but inadequate advising can factor into students' decisions to switch out of STEM majors (Tsui, 2007 and Blash et al., 2012). In our study, survey responses were divided on the level of satisfaction students

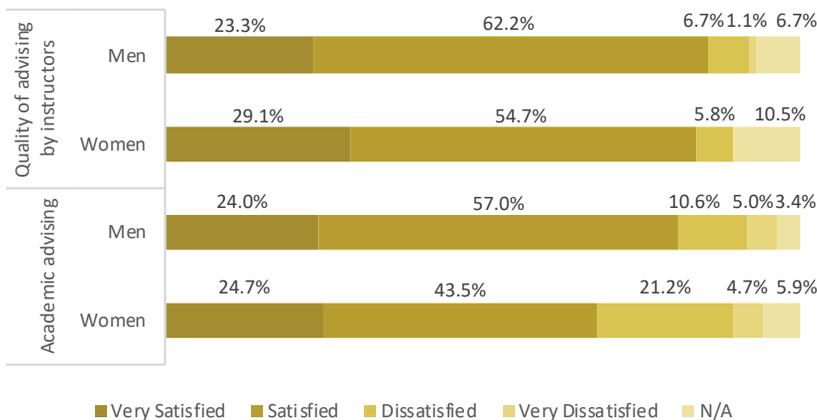
experienced with advising at their colleges. Women reported higher levels of dissatisfaction with academic advising than men, and both men and women expressed higher satisfaction about the quality of advising from instructors than from academic advisors (Figure 3). Most students we spoke with had relatively negative impressions of their college advisors.

"[Advisors] never put themselves in the student's shoes. So the explanation is really uncaring, I guess? It's not like they are, you know, being mean to us or anything. But they don't understand us at all."

Of particular concern were issues that arose regarding incorrect information about transfer requirements from college advisors. One student expressed her frustration, saying that what she has been told "just hasn't turned out to be true a lot of the time."

Additional factors influencing persistence in engineering and computer science. Students expressed challenges they have experienced due to financial barriers, academic preparation, and lack of family support that they felt could have a negative impact on their progress toward an ECS degree. When asked what issues might cause them to withdraw from class or college, top responses from women in our survey were lack of finances, working full time, and being academically unprepared. This compares to men's top responses of lack of finances, caring for dependents, and working full time.

Figure 3: Satisfaction with Advising



Finances play an important role in students' decisions to enroll in two-year institutions. Educational costs vary depending on the program a student selects, with courses in engineering and science being more expensive than those in the humanities and social sciences (American Academy of Arts and Sciences, 2016). Most interview respondents in our study discussed the financial challenges they faced and the necessity of working while in school. For these students, financial strain was their primary reason for attending community college rather than starting at four-year universities.

Students also mentioned during the interviews some of the family commitments that limit the time they can devote to their studies. A couple of students mentioned certain health issues they faced that affected their attendance and finances, while others noted the impact partners and children have had on their educational trajectories.

Some students expressed concerns related to their academic preparation for college coursework, noting that their high school lacked resources for certain advanced coursework that many other schools are able to provide. Older students mentioned a fear of having lost some fundamental math skills due to the amount of time that had passed since high school. Still others mentioned nervousness about their levels of academic preparation prior to transferring to a university to complete their degrees.

While the students we interviewed indicated that their families were generally supportive of their pursuits of ECS degrees, faculty we spoke with noted instances of students expressing a lack of support from their families, particularly among first-generation students. For many, they had no one in their families who had attended college, much less pursued a degree in a math-and-science-intensive program. For others, it stemmed from the gendered stereotypes of appropriate careers for women.

"I've had women come in and tell me that, you know, 'My parents won't pay for me to study engineering because it's just not an appropriate occupation for a woman. It's okay for my brother, but it's not okay for me.'"

RECOMMENDATIONS

We conducted this study to gain a better understanding of the challenges and barriers facing women on the transfer pathway in their pursuits of ECS baccalaureate degrees. Based on the findings from our first study of ECS transfer success in Texas, we expected to find gendered differences that would lead us to clear recommendations to improve women's retention in these programs. Instead, we discovered that all genders face similar challenges on this pathway, and only a few of these challenges are felt more strongly by women. In some cases, our observations aligned with prior research, while others were unexpected.

The following recommendations could help better support women on the transfer pathway in ECS, but our findings indicate that all genders would benefit from many of these improvements.

- **Improve advising for transfer students.** Students in our study reported feeling uncertain about the help they received from their college advisors. Faculty we spoke with expressed an expectation that students should be proactive in reaching out to the transfer institution for information about courses they should take at the community college. While a number of students indicated they were able to find the help that they needed, it is those students who are unsure how to navigate the college environment, and who are in most need of guidance, who may be falling through the cracks.
- **Provide more financial support.** For many students, cost is the primary reason for beginning their baccalaureate degrees at a community college. Some students in our study spoke of the impact working full time while taking classes had on their ability to make time for school-related activities, including enrolling full time. Scholarships and other forms of financial support could help give students more time to focus on their ECS studies. Paid internships and other forms of employment that expose students to hands-on engineering projects while also providing monetary support as they pursue their educations could help retain students in ECS programs.
- **Provide more information about career pathways.** More than half of the students in our

study expressed limited or no knowledge about the engineering profession prior to entering college. Students we interviewed reported that learning more about the range of opportunities available within engineering would help them narrow their choices of major and develop plans for their futures. Fostering connections with professional engineers could be very valuable for women in community college by exposing them to the different career paths and opportunities available to them if they complete their ECS degrees.

- **Strengthen interpersonal relationships, networking, and mentorship.** Students stated that they knew involvement in extracurricular activities could benefit them academically, socially, and professionally. While a number of students we interviewed said they were interested in joining professional societies, few were members of such organizations. Events that allow women engineers to talk about their jobs or interact with university students who have successfully transferred into ECS majors from a community college could help foster relationships with students at universities to which they are considering transferring as well as build their support and professional networks.
- **Focus on boosting confidence.** Aligning with prior research, women in our survey tended to be less confident in math and science than men. Research suggests that interventions such as providing opportunities for undergraduate research and connecting women with same-gender STEM experts can counteract stereotypes and increase confidence of women (Russell et al., 2007; Stout et al., 2011). Increasing women's confidence can have a measurable impact on both performance and persistence in STEM.

Additional findings from this study can be found in the full research report, *Diversifying STEM: Increasing Women's Persistence on the Transfer Pathway in Engineering and Computer Science*. To download a copy of the report, visit <https://research.swe.org/>. This research was made possible by the generous support of the Society of Women Engineers' Corporate Partnership Council and the Northrop Grumman Foundation. ❖

Endnotes

1. Major switching was assigned to the institution where the student first declared an ECS major, though the student may have switched majors after transfer.
2. Time-to-degree was not considered, as long as the student received a bachelor's degree before the 2011-12 academic year (the last year of available data).
3. Previously validated measures from the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) and the Academic Pathways of People Learning Engineering (APPLES2) were used to develop survey questions.
4. The Texas Success Center coordinates the Texas Pathways strategy. Information about this program can be found at <https://tacc.org/tsc>.

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Increasing the Diversity of Patent Recipients

A look at efforts to broaden the participation of underrepresented groups in the patent process offers promise, while at the same time points to other problems in the patent system.

By Sandra Guy, SWE Contributor

The federal government is working to identify and encourage women, minorities, and veterans to secure patents for their innovations, but skeptics say the patent process itself needs to be fixed first. The effort to gather data on underrepresented groups, encourage them to innovate, and track the results is known as the SUCCESS Act. The acronym reflects the federal legislation that started the initiative: the Study of Underrepresented Classes Chasing Engineering and Science Success Act of 2018.

Because the patent office does not collect demographic data during the patent application process, it is difficult to accurately determine the numbers. But an analysis released in February 2019 revealed that the number of patents with at least one woman inventor stood at 21% in 2016, up from 7% in the 1980s, according to the U.S. Patent and Trademark Office.

Laura Peter, J.D., deputy director of the patent office, said in an emailed statement that to implement the SUCCESS Act, the office has “undertaken a proactive approach to encourage women, minorities, and veterans to innovate and secure patents to protect their innovations.”

This takes place in a number of ways. “We provide guidance and assistance to inventors, host annual events such as our Invention-Con and Women’s Entrepreneurship Symposium, support pro bono networks around the country, offer pro se assistance to make navigating the patent process more accessible (especially to first-time applicants), and have free legal services through 60 participating law school clinics,” Peter said.

“We also have four regional offices to help make the IP [intellectual property] system and the

[patent office] more accessible to inventors, entrepreneurs, and small businesses throughout the country,” she added. “Also, our Patent and Trademark Resource Centers are located in more than 80 public, state, and academic libraries — many in minority and underserved communities. These centers offer regular programming, virtual office hours with [patent office] subject-matter experts, and librarians trained to assist with intellectual property research.”

UNDERREPRESENTATION IS PART OF A LARGER ISSUE

A series of public hearings regarding the Success Act exposed issues that point to a much bigger problem, however. Skeptics and critics, including women and underrepresented minorities, say that despite the act’s best intentions, a 2011 federal law changed the patent system to make it virtually impossible for small businesses and independent innovators to keep the patents they worked so hard to obtain.

Among the groups submitting comments, US Inventor, a nonprofit representing 13,000 individual inventors and small businesses, pointed out that the current patent process “virtually precludes success” for all underrepresented patent owners. “Instead of providing a chance for underrepresented and underprivileged individuals to move up the social ladder, involvement in the patent system is more likely to drag them into unwinnable battles that will drain their life savings and leave them utterly destroyed,” the group said, urging the USPTO to include more protections for independent inventors.

The 2011 law was designed to fight patent trolls — companies that make money on patent-infringement lawsuits by acquiring patents cheaply and then charging licensing fees to other businesses and people who appear to infringe on those patents. But it turned out to be much more. At the center of the controversy is the establishment of the Patent Trial and Appeal Board, or PTAB, which, during the American Intellectual Property Law Association annual meeting in 2013, Randall Rader, J.D., a former Federal Circuit chief judge, labeled “a death squad” for killing property rights.

Lawyers disagree whether the PTAB offers a fair hearing. But critics point to the fact that the administrative patent judges who serve on the PTAB are unrestrained from any code of judicial conduct and have ruled on cases involving former clients.

Carrie Hafeman, an inventor and founder of two companies, said her

10 patents covering computer and electronic-device security are “extremely difficult to assert” because big technology companies have usurped her innovation without

licensing it. The tech companies often preload her patented features into smartphones, laptops, PCs, tablets, and even watches, she said.

She said she has been unsuccessful even trying to amicably license or sell her patents because of the U.S. patent situation and PTAB controversy. That’s despite her early successes, including first applying for a patent in 2002; placing No. 1 among 175 startups in a 2011 Vator Inc.-sponsored competition for her computer-security product invention; and initially counting among her security-product clients such major retailers as Staples and Office-Max, as well as UCLA, the University of Southern California, Cornell University, Johns Hopkins University, and others.

“The PTAB department *re-reviews* patents that [the patent office] has already issued — and often years later — to see if they should have given the inventor a patent in the first place,” said Hafeman, whose elder daughter is an environmental engineer and younger daughter a biochemical major.

“When the PTAB eliminates U.S. patents already issued, this allows not only U.S. companies to copy ideas from U.S. inventors and willfully infringe their patents, but also foreign companies now get a green light to copy the U.S. inventor’s ideas,” she said.

“This not only hurts current inventors in this country, but [hurts] all kinds of companies that could be created, as well as investors, shareholders, and employees,” Hafeman said. “This hurts and discourages American innovation and impacts young future inventors in this country.”

After a SUCCESS Act public hearing held May 8, 2019, at the patent office’s headquarters in Alexandria, Virginia, 20 of the women, minority, and veteran inventors who testified wrote a letter protesting that their concerns were relegated to an appendix and excluded from the patent office’s final legislative report.

The inventors and patent holders had testified that they foresaw huge obstacles to enforcing their patents; risks of their patents being invalidated by the

PTAB that the 2011 law created; and they feared that big companies will deliberately choose to infringe their patents because it’s cheaper to do so than to license the patents.

Peter, through a spokesperson, declined comment on the patent process controversies or the effects of the 2011 legislation.

DESPITE THE CONTROVERSIES

The critics say they remain hopeful that proposed new legislation may improve the situation.

The bipartisan proposal (H.R. 5478) is sponsored by U.S. Rep. Danny Davis, Ph.D., D-Ill., and U.S. Rep. Paul A. Gosar, D.D.S., R-Ariz.

Dr. Davis, a 24-year veteran congressman from Chicago, posted on his website that the proposed law would let inventors who own their patents opt out of PTAB. “Accused infringers will have the right to challenge validity [of a patent] in a regular court of law, which is how the U.S. patent system worked for our first 190 years [prior to the 2011 legislation],”

“THIS NOT ONLY HURTS CURRENT INVENTORS
IN THIS COUNTRY BUT HURTS ALL KINDS OF
COMPANIES THAT COULD BE CREATED, AS WELL AS
INVESTORS, SHAREHOLDERS, AND EMPLOYEES.”

– Carrie Hafeman, inventor, founder of two companies

according to the website.

In an interview, Dr. Davis said, “Some of [the inventors] are so frustrated. They swear to high heaven they’ve seen their hard work and creative ingenuity just zapped [by major companies].”

“We think the legislation — if we ever get it passed, and even in the process — allows a chance to talk about the issue,” Dr. Davis said. A resolution supporting the Davis-Gosar legislation can be found at <https://www.usinventor.org/inventor-rights-act/>.

Amid the uproar, SUCCESS Act proponents say there’s one positive: the increased collection of demographic data among those who participate in patenting and trademarking. “Done right, this step can help federal agencies conduct outreach and provide resources to increase women’s participation in STEM fields, translate their experience and knowledge into patentable opportunities, and start ventures,” said Andrew Morse, assistant to the president for board and governmental relations at the University of Northern Iowa.

That could translate into billions of dollars in economic growth. The USPTO’s own “Intellectual Property and the U.S. Economy: Industries in Focus” study found that IP-intensive industries directly and indirectly support 45.5 million jobs — nearly one-third of all U.S. employment — and the share of total U.S. GDP (gross domestic product or the value of a country’s economic activity) attributable to IP-intensive industries is about 40 percent (\$6.6 trillion).

If just 1% of the 250,000 women who graduate each year with science and engineering degrees received patents, that would translate into 75,000 women in total, and 7,500 black women, says Erika Jefferson, a chemical engineer and president and founder of Black Women in Science and Engineering (BWISE). “Estimating the financial benefits would be very difficult, but based on the patents granted today, it would most definitely be in the billions of dollars,” she said.

Jefferson said her awareness was heightened when she worked on a Feb. 22, 2020, celebration of the life and achievements of the late Patricia Bath, M.D., the first African American to complete a residency in ophthalmology, at New York University, and the first black female doctor to receive a

medical patent. Dr. Bath invented the Laserphaco Probe to treat cataracts in 1986. She worked as an assistant professor of surgery at Charles R. Drew University and at UCLA and, in 1975, she became the first female faculty member in the department of ophthalmology at UCLA’s Jules Stein Eye Institute.



Erika Jefferson

The SUCCESS legislation also aims to expand the use of grant funds for activities that promote invention and entrepreneurship among women, minorities, and veterans. To do that, women’s advocates need to work closely with the patent office to make sure those funds have the greatest impact, Jefferson said. “My plan is to be an advocate,” she said. “It is critical that [the patent office] implement much-needed changes with the data it collects.” ✨

Sources

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An Essential Tool



Every year, SWE tackles the difficult task of summarizing a year's worth of broad-ranging, interesting, and timely research about women in engineering. SWE's annual literature review, now in its 18th year, serves as a summary of the most significant research on women in engineering and STEM published in the past year. The literature review team selects from hundreds of articles, research studies, books, and papers on relevant subjects, in a variety of disciplines, to develop this comprehensive document. The literature review provides analysis and insight into the research questions social scientists pose regarding the experiences of women in engineering, as well as experiences of female students in university classrooms and community colleges.

Among the focus areas in this year's State of Women in Engineering issue are insights into the current state of mind of SWE members and ways employers can attract and retain the best and most diverse engineering talent in their industry. In collaboration with People at Work, SWE conducted a survey of women engineers in the workforce to understand what they seek from employers. The findings from this survey of more than 2,900 women engineers help uncover areas of focus for employers who want to improve the employee experience for women in engineering and technology at their organizations.

We also take another look at students in community colleges moving into four-year engineering curricula. Phase I of this study was completed and discussed in the 2018 literature review. Phase II, completed in 2019, offers a compelling look at why this pathway toward an engineering degree has the potential to increase diversity in the engineering workforce. Results and conclusions from Phase II of the study indicate that improved advising is needed for transfer students, and more financial support is critical. Focusing on providing more information on career pathways, strengthening of mentoring and networking relationships, and boosting students' confidence are critical for persistence in STEM for transfer students.

The articles we've noted here represent only a portion of this issue overall. We encourage you to become familiar with the wealth of information contained herein. Our State of Women in Engineering issue is an essential tool on the path of fulfilling the SWE mission and achieving a diverse engineering workforce. Thank you for joining in this important endeavor.

Cindy Hoover, F.SWE
FY20 SWE President

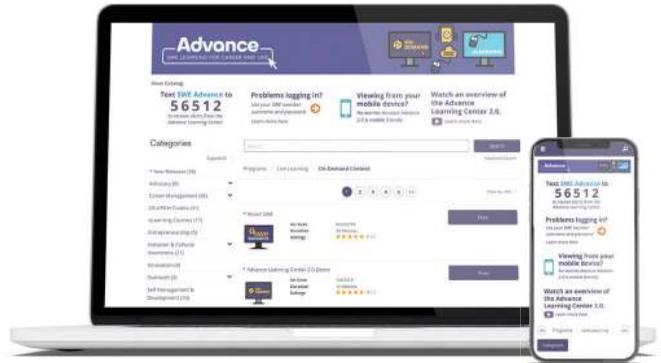
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- Diversity in Engineering Matters: Coaching, Mentorship & Sponsorship



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- Global Collaborations: Working on and Leading Remote Teams
- Strategic Leadership Series
- One Size Does Not Fit All - How Leaders Can Leverage Executive Presence
- SWE Advocacy - Impacting Policy at the National Level



Diversity & Inclusion

- A Critical Update: Changes to Title IX Implementation and the Impact on Women in Engineering
- Closing the Leadership Gender Gap
- Confronting Gender Bias - Men and Women as Diversity Partners
- Managing Diverse Teams
- Frenemies: The Brain Science Behind the Dynamic Cooperative/Competitive World of Women's Leadership

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