Thinking Differently About Design and Research
Thinking Differently About Design and Research
OPENING THOUGHTS

3 Opening Thoughts
4 Women in Engineering: A Review of the 2016 Literature
38 Thinking Differently About Design and Research
46 A Deeper Look at Gender and Racial Bias
58 Title IX at 45
64 Growing an Ecosystem to Ensure Gender Equality
68 Final Words

Toward Effective Solutions

Welcome to SWE Magazine’s special issue devoted to research! This is the first time we’ve brought together in a single publication the latest annual literature review; details on SWE’s most recent research; plus a thoughtful look at gender, research, and policy, and ways the interrelationship between them is understood and applied.

This spring marks the 15th anniversary of the annual SWE literature review, our examination of the previous year’s social science literature concerning women in engineering and other STEM disciplines. The literature review has been a staple every year since its debut in 2002, and it forms the backbone of this special issue. In addition to an extensive bibliography, the authors provide a detailed analysis and discussion of the most interesting and important research — shedding light on the reasons for women’s persistent underrepresentation in engineering and other technical fields, as well as insights toward effective solutions.

In this issue you will also find:

- Thinking Differently About Design and Research
- A Deeper Look at Gender and Racial Bias
- Title IX at 45
- Growing an Ecosystem to Ensure Gender Equality

This is the first time we’ve brought together in a single publication the latest annual literature review; details on SWE’s most recent research; plus a thoughtful look at gender, research, and policy, and ways the interrelationship between them is understood and applied.

While this is our first-ever magazine focused on research, attention to research and conducting research is not new to SWE. In fact, data gathered by SWE from surveys of prospective members was used in the U.S. Department of Labor’s Women’s Bureau Bulletin beginning in 1954.

More recently, SWE has expanded its own research efforts, under the direction of Roberta Rincon, Ph.D., manager of research. Dr. Rincon is a contributor to this issue (see “A Look at Gender and Racial Bias”) and to the many discussions we’ve had in conceptualizing and bringing this publication to fruition.

Conducting research, analyzing that research, and posing and pursuing new research questions — these undertakings inform us in establishing best practices to diversify the profession. These same efforts will also help to ensure a robust and diverse pipeline of future engineers and STEM professionals. We hope this publication is a productive part of that journey.

Anne M. Perusek
Director of Editorial & Publications
anne.perusek@swe.org
Women in Engineering: A Review of the 2016 Literature

The amount of public attention devoted in 2016 to the role of women in engineering and science can only be called striking. Several “popular” historical books (see sidebar) drew attention to the little-known story of the centrality of African-American women to the space program atNASA.

By drawing attention to these hidden stories of female achievement in science and engineering, these books (and film) make contemporary audiences aware both of the often unacknowledged contributions women have already made in these fields and of the potential for them to contribute far more. At the same time, they create a sense that there has been real progress — the overtly sexist and racist practices described in Hidden Figures (Shetterly, 2016), was made into a field Hollywood film that made large audiences aware of the previously little-known story of the centrality of African-American women to the space program atNASA.

The report also describes successful initial efforts to improve the situation, such as universities’ experimenting with dropping math and physics standardized tests as prerequisites and offering courses on “humanitarian engineering” designed to be attractive to a more diverse student body.

Of course, not all of the popular media attention was entirely sympathetic to women’s involvement in science. Facebook accounts continued to “share” an article published in 2015 in Breitbart by Milo Yiannopoulos, the controversial conservative speaker who has received much attention during 2016 and early 2017 (Yiannopoulos, 2015). The article, making rather loose use of research done at Cornell University by Ceci and Williams (discussed in this literature review in previous years), proposes that there should be limits on the numbers of women allowed to enter STEM fields since the research “shows” that they either can’t compete or drop out voluntarily when they decide that they want to pursue other goals. Yiannopoulos’ argument runs directly counter to the predominant theme in popular coverage of women in STEM, exemplified by the article in Scientific American mentioned above: the view that American science needs more women if it is to compete with emerging scientific and technical powerhouses across the globe.

So, this year more than most, nonspecialist audiences heard (and learned) a great deal about the situation of women in engineering and STEM more broadly. But, these popular accounts can take us only so far. They certainly made us aware of the fact that women have made important contributions to science and that we have made some progress toward gender integration. But, how much progress has been made and how many of the traditional barrierson gender equity have been eliminated? Indeed, what do we know about what actually causes the underrepresentation of women in engineering? Answers to these and similar questions can be answered only by careful, objective attention to scholarly research.

The selective, misleading use of academic research by public figures such as Yiannopoulos also points to the importance of engaging directly with what that research actually says. We offer this year’s literature review summarizing current research on women in engineering as part of SWE’s continuing effort to deepen our understanding of the current realities by improving access to the best research in the field.

We reviewed more than 250 books and articles published in the past year, located by an extensive search of the social scientific and engineering literature. We were impressed, this year, by the significant number of well-designed studies we reviewed. Of course, the quality of the research published each year varies tremendously. As in previous years, we read some exemplary studies that drew on extensive research, employed the best scientific methods, and limited their conclusions to what the evidence would support; other studies were based on limited data and imperfect samples, and often marked by personal opinion. In the review that follows, we have focused on those studies that genuinely merit serious attention because they were scientifically sound and/or because they raised important questions or pointed to significant new lines of inquiry.

As we will argue in greater detail below, this year’s scholarly literature on women in engineering has much to tell us. We learn from it that the small numbers of women in engineering have less to do with ability and more to do with the reality that engineering continues to be perceived as a masculine field and to present itself in ways that don’t speak to the values and objectives that many young women emphasize. This gendering discourages women from entering engineering in the first place and, when they do enter, makes it hard to feel they belong. We also learn that women are more likely than men to leave engineering, especially after they have earned a degree. And, the reasons for their departure are becoming increasingly clear: Women leave engineering because of work/family conflict, and because they discover that they don’t find the kinds of opportunities and support to pursue their professional and personal goals. There are also lessons to be learned from this literature about the possibilities for change: There are, in fact, interventions that work, or that have real promise, so we needn’t accept women’s underrepresentation as inevitable.

2016 LITERATURE REVIEW

By Peter Meikins, Ph.D., Cleveland State University
Peggy Layne, P.E., F.SWE, Virginia Tech
Kacey Beddoes, Ph.D., University of Massachusetts Lowell
Sarah Masters, Virginia Tech
Micah Roediger, Virginia Tech
Yashna Shah, Virginia Tech

Women in Engineering: A Review of the 2016 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 drawing attention to these hidden stories of female achievement in science and engineering, these books (and film) make contemporary audiences aware both of the often unacknowledged contributions women have already made in these fields and of the potential for them to contribute far more. At the same time, they create a sense that there has been real progress — the overtly sexist and racist practices described in Hidden Figures (Shetterly, 2016), was made into a field Hollywood film that made large audiences aware of the previously little-known story of the centrality of African-American women to the space program atNASA.

By drawing attention to these hidden stories of female achievement in science and engineering, these books (and film) make contemporary audiences aware both of the often unacknowledged contributions women have already made in these fields and of the potential for them to contribute far more. At the same time, they create a sense that there has been real progress — the overtly sexist and racist practices described in Hidden Figures (Shetterly, 2016), was made into a field Hollywood film that made large audiences aware of the previously little-known story of the centrality of African-American women to the space program atNASA.

By drawing attention to these hidden stories of female achievement in science and engineering, these books (and film) make contemporary audiences aware both of the often unacknowledged contributions women have already made in these fields and of the potential for them to contribute far more. At the same time, they create a sense that there has been real progress — the overtly sexist and racist practices described in Hidden Figures (Shetterly, 2016), was made into a field Hollywood film that made large audiences aware of the previously little-known story of the centrality of African-American women to the space program atNASA.

By drawing attention to these hidden stories of female achievement in science and engineering, these books (and film) make contemporary audiences aware both of the often unacknowledged contributions women have already made in these fields and of the potential for them to contribute far more. At the same time, they create a sense that there has been real progress — the overtly sexist and racist practices described in Hidden Figures (Shetterly, 2016), was made into a field Hollywood film that made large audiences aware of the previously little-known story of the centrality of African-American women to the space program atNASA.
Still, as we have noted in the past, the scholarly literature on women in engineering is not without its limitations. In fact, one article we reviewed this year did an excellent job of summing up the weaknesses in that literature. Pawley, Schimpf, and Nelson (2016) conducted a content analysis of articles published in ASEE’s Journal of Engineering Education over the 15-year period from 1998-2012. They found much excellent research, but also that much of it (probably too much of it) adopted similar methods and focused on similar issues.

Specifically, they found that most of the research utilized quantitative methods to the exclusion of other methodological approaches. Researchers also utilized a narrow set of theoretical frameworks, particularly the idea that a pipeline metaphor was useful for understanding women’s situation in engineering. Finally, Pawley and her collaborators found that the vast majority of the articles they reviewed were conducted in university research.

Lab Girl

Hope Jahren, Ph.D., a distinguished geobiologist who is “the only woman to receive a Young Investigator Award in the health sciences, has written a memoir of her still young career, titled Lab Girl (Jahren, 2016). In it, she describes how she first discovered her interest in science while accompanying her father to the community college labs he oversaw. She goes on to tell a series of engaging stories detailing the experiences she and her longtime lab partner, “Bill,” had as she moved through the various stages of an academic scientist’s career.

The title of the work implies that Dr. Jahren intended to write a book about being a woman in the world of scientific research. In the end, however, this does not seem to be her real goal. Rather, her focus is much more on conveying the excitement that accompanies scientific research; on describing the hard work, the peculiar hours, and work conditions; and the camaraderie she enjoyed with her lab partner and graduate students. One gets a real feel, from the memoir, of what it is that Dr. Jahren really enjoys in scientific work and a sense of the sacrifices required and the rewards available to a dedicated research scientist.

Is Lab Girl the sort of book that might inspire young women to consider a scientific career? Might it spark changes in research science that would make it more welcoming to a larger number of young women? Dr. Jahren certainly communicates how much she enjoys the work she does and describes a world in which creativity, curiosity, and initiative are central. She also acknowledges the reality that being a woman in research science is both unusual and difficult. Thus, she discusses being accepted as a scientist despite being a “girl.” She describes the sexist attitudes and behaviors she encountered among male scientists with whom she worked on a field trip in the Arctic and the difficulties she encountered with male colleagues and superiors as a pregnant woman in a lab. She also notes her realization, early on, that to be successful, she would have to be twice as strategic and proactive as her male counterparts.

In the end, however, she seems to accept that being a scientist and being a woman in any conventional sense are more or less incompatibile. As she puts it early on, “On some deep level, the realization that I could do good science was accompanied by the knowledge that I had formally and terminally missed my chance to become like any of the women I had ever known.” (p. 71)

Although she eventually does marry, and have a child, she treats this almost as a happy accident and emphasizes the importance of her husband’s unusual ability to move his career to accommodate the demands of her work. Dr. Jahren seems to take for granted, even to celebrate, the enormous demands of a scientific career that make being a “normal” woman impossible. As she puts it, “I am a female scientist, nobody knows what the hell I am, and it has given me the delicious freedom to make it up as I go along.” (p. 277)

One wonders whether a “typical” young female reader, interested in a scientific career, would be as accepting of the fact that a woman just has to deal with sexism and unreasonable work arrangements. Or would she be as confident of her ability to make a go of it in the absence of institutional supports?

Failing Families, Failing Science

Where Lab Girl (Jahren, 2016) documents the experiences of a female scientist who has had a successful career (and a family) by adapting to and dealing with the unrelenting demands of academic science, another book published this year, this one an academic study of work/family conflict in academic science, makes the case that science must adapt to the needs of families if it is to attract and retain the nation’s best and brightest.

Failing Families, Failing Science: Work-Family Conflict in Academic Science, by Elaine Howard Ecklund, Ph.D., and Anne E. Lincoln, Ph.D. (2016), reports on research conducted on a group of biologists and physicists at the top 20 American universities between 2008 and 2011. The authors make an impassioned case that the inflexible expectations of academic science pose a threat to the quality of science itself. As they put it: “It is a national problem if the family-unfriendliness of academic science is a turnoff for the most talented men and women.” (p. 15)

Dr. Ecklund and Lincoln find that there continues to be an expectation in academic science that all research scientists should be “ideal scientists,” willing and able to make work their top, and more or less exclusive, priority. This ideal emerged in an era when most scientists were men, married to women who could devote time to the family work that male scientists were unable and unwilling to do. While this ideal persists, however, realities have changed. Increasing numbers of scientists are women, most of whom hope to have conventional family lives as well as scientific careers. Importantly, Drs. Ecklund and Lincoln report that increasing numbers of young male scientists also report that they are looking for career/family balance. At the same time, the demands of an academic career have increased. It takes longer to achieve a stable academic position, as prolonged graduate training and postdocs have become increasingly normal, and, the time demands of the scientific career have grown as the pressure (and difficulty) of obtaining funding have increased.

The result, according to Drs. Ecklund and Lincoln, is that many young scientists actively consider careers outside academic science (or even outside science altogether) and many actually follow through and leave. Both female and male scientists are frustrated by the time demands involved in managing a scientific career and a family, and few have a nonworking spouse at home to shoulder the domestic burden (in fact, many are married to other scientists, creating the “two-body” problem of finding two professional jobs in one location). Many feel guilty, either because they are not able to devote sufficient time to scientific research (which may experience a moral obligation to pursue ultimate truths) or because they are pulled away from their children and the family activities they value. And some are frustrated by the need to have fewer children than they want, later in their lives than they had wanted.

Although Drs. Ecklund and Lincoln are at pains to argue that men as well as women experience these conflicts, their research shows that the problem continues to be most acute for female scientists. Female scientists report experiences of discrimination (being blamed for missing meetings because “you’re a mother”) and not being rewarded (or even being viewed negatively) for doing “supportive” work such as advising and mentoring students. Although the women surveyed report working similar hours to their male counterparts, they also report feeling more time conflicts and state, inaccurately, that they cannot work the same hours as their male colleagues. Likely, this reflects the greater pressure on women to perform domestic work and the different ways in which that work is framed for men and women: “Men may have time with family and help with child care, but they are not yet culturally expected to care for household activities. Scientist mothers, on the other hand, are expected to fulfill the obligations of ‘ideal full-time roles.” (p. 98) This review is all about being “lucky” (if their husbands help out at home), while men are described as “making sacrifices” when they devote time to family.

The authors argue that academic science is losing some of its most promising young practitioners, both male and female, to this conflict. Unless the “ideal scientist” model is abandoned, and universities begin to do things such as expanding family-friendly policies to graduate students and postdocs, making stepping the tenure clock routine, and taking steps to moderate the time demands involved in grant management, many scientists are likely to leave the academy for the more accommodating opportunities available elsewhere.

Abandoning the ideal scientist model involves more than just changes in policy. Drs. Ecklund and Lincoln argue that it requires a fundamental cultural change in academic science that will make it a very different experience from the one Hope Jahren, Ph.D., describes in Lab Girl.
settings and that very few focused on business and industry. Our literature review is broader than the one conducted by Pawley, Schimpf, and Nelson, but it leads us to support their calls for a greater diversity of theories and research designs and for increased focus on the nature of engineering outside the educational system.

WHERE DO THINGS STAND?

First, it is worth emphasizing that women continue to be underrepresented in engineering by virtually any measure one can find. The data presented in this review and in greater detail in Yoder (2016) reveal that, in 2015, women earned 19.9 percent of engineering bachelor’s degrees, 25.2 percent of master’s degrees, and 23.1 percent of doctoral degrees, in each case reflecting a slight increase over the previous year. Women represented only 15.7 percent of faculty in engineering programs, up from 15.2 percent in 2014 and up from 13.3 percent in 2006. In an era of growing engineering enrollments, these data represent relatively important increases in the numbers of female engineering graduates. Still, women continue to be a minority in engineering, and the progress, while real, has been extremely slow.

Importantly, women are not evenly distributed across engineering fields and institutions. For example, women earned almost half (49.7 percent) of bachelor’s degrees in environmental engineering and 40.9 percent of bachelor’s degrees in biomedical engineering, while they earned only 13.5 percent of bachelor’s degrees in electrical engineering and 10.9 percent of bachelor’s degrees in computer engineering. Some schools have been more successful in graduating female engineering students and/or in recruiting female engineering faculty. Thus, schools such as the Olin College of Engineering and the Massachusetts Institute of Technology (MIT) grant almost half of their undergraduate engineering degrees to women; at Yale, 43 percent of master’s degrees in engineering went to women; and at Northeastern, 43.4 percent of doctoral degrees in engineering were earned by women. Women are significantly more than 15.7 percent of the engineering faculty at a number of institutions (including Seattle Pacific University, where they make up two-thirds of the faculty, and Smith College, where they are 62.5 percent). Unfortunately, many of the schools with higher female faculty representation are not among the large, prestigious universities that grant the largest numbers of engineering degrees, so their impact on overall numbers is modest. Nevertheless, cases such as these indicate that women’s underrepresentation need not be permanent, and that it is possible to achieve something resembling gender balance in the field.

Women in engineering and STEM also tend not to be as well compensated as their male counterparts. Two studies we reviewed this year provided some insights into why. Tao (2016) analyzed data from the 2008 National Science Foundation Survey of Doctorate Recipients, finding that women with engineering doctorates are more likely than men to be in academic research, teaching, government research, and other government positions, while comparable men are more likely to be employed in industry. Buffington et al. (2016) used data from the Umetrics™ files — which include all individuals employed on federal research awards — and linked them to data from the 2010 census. They isolated a sample of 1,257 students who had Ph.D.s and were employed on grants. The men in their sample were much more likely than the women to have done dissertations in engineering, math, physics, or computer science and, for all fields, were more likely to be employed in industry. This study confirmed that women are more concentrated in academic and government positions. Buffington et al. argue that this pattern partially explains women’s lower wages in engineering and other STEM fields, as industrial positions tend to be more lucrative.

THE PRIMARY QUESTION

We know that women continue to be underrepresented in engineering. The question remains: Why? This has been and continues to be the issue that dominates the literature on women in engineering. There continue to be multiple answers to this question, but they tend to cluster around two broad concepts:

- Women are underrepresented in engineering because women are less likely than men to pursue an educational pathway that leads to an engineering degree; and/or
- Women who are attracted to engineering as a field and start down the road toward an engineering career are more likely than their male counterparts to leave.

A substantial amount of research, including a number of studies we reviewed this year, argue that the low numbers of women in engineering are the result of the small numbers of women who are attracted to the field in the first place. School-age girls, when they are considering potential college majors and careers, are less likely than comparable boys to select engineering as an option. Because engineering is a field of study one needs to enter early — given the complex ladders of requirements one must complete and the need for advanced coursework — the choices girls (and boys) make in high school, and even before, play an important role in limiting the numbers of women in the field.

WHY DO SO FEW WOMEN CHOOSE TO STUDY ENGINEERING?

The question thus becomes, why do relatively few women choose engineering and why is the field more attractive to young men? At least three answers emerged from this year’s research literature, although there remains considerable debate about each:

- Engineering does not present itself as a field consistent with the values and goals of many young women.
- Young women in math and other courses that lead to engineering are more likely to experience self-doubt regarding their ability to persist as engineers.
- Engineering continues to be perceived as “masculine,” so young women don’t see it as a viable option for themselves.

YOUNG WOMEN’S GOALS AND CAREER OBJECTIVES

Several studies we reviewed this year repeated a claim made in past research — that young women are not drawn to engineering because they don’t
2016 Outstanding Women in Engineering
By Micah Roediger

American Society for Engineering Education (ASEE) Awards

JAMES H. MGCRRAW AWARD
Carol Richardson, Ph.D., Rochester Institute of Technology

NATIONAL OUTSTANDING TEACHING AWARD
Mary Verstraete, Ph.D., The University of Akron

SHARON KEILLOR AWARD FOR WOMEN IN ENGINEERING EDUCATION
Karen C. Davis, Ph.D., University of Cincinnati

WILLIAM ELGIN WICKENDEN AWARD
Debra M. Friedrichsen, Ph.D., CEO and Engineering Consultant, MJ Innovations

The University of Akron

By Micah Roediger

2016 Outstanding Women in Engineering (SWE) Awards

Society of Women Engineers (SWE) Awards

ACHIEVEMENT AWARD
Stephanie Watts Butler, Ph.D., P.E., Texas Instruments

SUZANNE JENNIKES UPWARD MOBILITY AWARD
Endowed by Northrop Grumman Corp.

Jill M. Hruby, Sandia Corporation

ENTREPRENEUR AWARD
Michele S. Stuart, Efficiency Engineers

DISTINGUISHED ENGINEERING EDUCATOR
Pamela M. Norris, Ph.D., University of Virginia

ADVOCATING WOMEN IN ENGINEERING AWARD
Natalie Hagan, The Johns Hopkins University Applied Physics Laboratory

The National Academy of Engineering (NAE) Awards

BERNARD M. GORDON PRIZE FOR INNOVATION IN ENGINEERING AND TECHNOLOGY EDUCATION
Kristin K. Wobbe, Ph.D., Worcester Polytechnic Institute

SIMON RAMO FOUNDERS AWARD
Ruzena Bajcsy, Ph.D., University of California, Berkeley

NEW FEMALE MEMBERS
Zhenan Bao, Ph.D., Stanford University
Emily A. Carter, Ph.D., Princeton University
Fiona M. Doyle, Ph.D., University of California, Berkeley
M. Cynthia Hipwell, Ph.D., Buhrer Inc.
Kristina M. Johnson, Ph.D., Cube Hydro Partners
Yilu Liu, Ph.D., Oak Ridge National Laboratory
Arati Prabhakar, Ph.D., Defense Advanced Research Projects Agency
Wanda K. Reder, S&G Electric Company
Ann Beal Salamone, Rechial Industries
Bridget R. Scanlon, Ph.D., The University of Texas at Austin
Kathryn D. Sullivan, Ph.D., U.S. Department of Commerce
Jennifer L. West, Ph.D., Duke University

EMERGING LEADER
Lindsay M. Forsyth, Chevron Corporation

SUZANNE GOODMAN, Intl Corporation

Christina Bishop Jackson, Ph.D., Honeywell

Jaime Gray Nelson, Booz Allen Hamilton

Siobhan Nyikos, The Boeing Company

Kelly Griswold Schable, The Boeing Company

Laura Schafer, Emerson Process Management

Rashi Tiwari, Ph.D., The Dow Chemical Company

Tracy Van Houten, Jet Propulsion Laboratory

Janis L. Mantini, F.SWE, The Boeing Company

Frances Stuart, Stuart Technical Services/Alpha Testing Laboratory (Retired)

Terry Comerford, Colorado State University

Erica Brackman, The Ohio State University

Alyssa Deardoff, Oregon Institute of Technology

Elizabeth Dreyer, University of Michigan

Katie Gonzagowski, University of Missouri–Kansas City

Danielle Johnson, The University of Texas at Austin

Rebecca Kandell, Polytechnic State University, San Luis Obispo

Anna Lucrezia Oldani, University of Illinois at Urbana-Champaign

Danielle Schroeder, Drexel University

Rachel Unruh, Texas A&M University

Society of Hispanic Professional Engineers (SHPE) Awards

SOCIAL IMPACT AWARD
Kathryn Finney, digitalunidivided

DENICE DENTON EMERGING LEADER AWARD
Colleen Lewis, Ph.D., Harvey Mudd College

A. RICHARD NEWTON EDUCATOR AWARD
Bhi Janet Shuford Fofang, College D’enseignement Technique Industriel et Commercial

CHANGE AGENT AWARD
Amanda Gicharu, Tech Republic Africa

The Anita Borg Institute for Technical Women and Technology Awards

The Anita Borg Institute for Technical Women and Technology Awards

DISTINGUISHED SERVICE AWARD

Janis L. Mantini, F.SWE, The Boeing Company (Retired)

M. Cynthia Hipwell, Ph.D., Buhler Inc.

Laura Schafer, Emerson Process Management

Rashi Tiwari, Ph.D., The Dow Chemical Company

Tracy Van Houten, Jet Propulsion Laboratory

Janet Willett, John Deere

SWE DISTINGUISHED NEW ENGINEER
Rachel Borchers, Boston Scientific Corporation

Gail Dyet, Boeing Incorporated

Lesley Farah, Starkey Hearing Technologies

Stuelt Gupta, John Deere India

Sunita G. Lavin, Garmin International

Jacquelyn K. Nagel, Ph.D., James Madison University

Rebecca M. Reck, Ph.D., Kettering University

Casey Griswold Waggy, Ball Aerospace and Technologies Corp.

Amanda Weissman, Partner’s Consulting

Allison Wright, Spirit AeroSystems

Jillian Hruby, Sandia Corporation

Kelly Griswold Schable, The Boeing Company

Sarah Adebaby, Inglewood, California

Lesley Arey, Lower Gwynedd, Pennsylvania

Jordan Love, Overland Park, Kansas

Sam Steinberg, New York, New York

The Anita Borg Institute for Technical Women and Technology Awards

THE YEAR

Dr. Janice A. Lumpkin Educator of the Year

Whitney Gaskins, Ph.D., University of Cincinnati

PRE-COLLEGE INITIATIVE STUDENT OF THE YEAR (FEMALE)

Olivia Martin, St. Louis

OUTSTANDING WOMAN IN TECHNOLOGY

Tracy Hamilton, Texas Instruments

Society of Hispanic Professional Engineers (SHPE) Awards

COMMUNITY SERVICE
Lorena L. Louriel, Lockheed Martin

JUNIPERO SERRA AWARD
Rosa Linda Puga, Lockheed Martin

PROMISING ENGINEER
Mariana Verdi, James Madison University

SHPE STAR OF TODAY AWARD
Adriana Sandoval, Chevron
perceive it as a field in which they can pursue their desire to work with people and to solve social problems and make the world a better place. Young women are said to have different professional goals and objectives than men and feel that they may not “fit into” the field of engineering.

Stout, Grunberg, and Ito (2016) surveyed a group of 136 undergraduates (71 women, 65 men) early in their first year in university. They asked their respondents to evaluate whether a variety of scientific majors offered opportunities for communion (maintaining relationships/serving society) or agency (autonomy/self-promotion). Three years later, the researchers examined what courses these students had taken. They found that students perceived fields such as engineering, math, and physics to offer fewer communal opportunities and more agency ones. Men took more courses in these fields; if women perceived these fields as offering communal opportunities, however, they were more likely to take such courses. Overall, the researchers concluded that the low numbers of women in fields such as engineering could be increased if the field were perceived as (and presented itself as) more communal.

Godwin et al. (2016) came to similar conclusions based on their examination of data from “Sustainability and Gender in Engineering,” a 2011 survey of 6,772 first-year students from 50 colleges and universities across the United States. They found, unsurprisingly, that having a strong math/physics identity was an important predictor of students’ choosing engineering as a major and career choice. They found that this was less true for women than for men, however. For women, “agency” beliefs were found to be important — i.e., the belief that one could improve the world through engineering. Godwin et al. conclude that efforts to recruit women to engineering by focusing exclusively on building their math/physics identities are likely to fail; attention also must be directed to persuading young women that it is possible to change the world through engineering.

It is worth remembering that Wang and Degol (2013) made a very similar argument earlier when they observed that a young person who is good at math may not choose to enter engineering if they believe the costs of doing so are too high and that the choice is not consistent with their values and goals. They noted, in their meta-analysis of the literature, that while the gender gap in math achievement has declined significantly, math-competent women continue to opt out of fields such as engineering while men are drawn to them.

Wang and Degol linked this to differences in values and goals, including women’s desire to work with people and their perception that fields such as engineering are “object-oriented.”

Miller (2016) presented results from implementation of a “culturally responsive” introductory computer science course at the University of California, Berkeley. It showed that women had a significantly stronger experience of belonging in the culturally responsive course than they did in the traditional introduction to computer science course, but that still only meant that 50 percent of the 388 women had a positive sense of belonging. Perhaps the largest takeaway from this study is that women’s sense of belonging was highly correlated with the computer science self-efficacy, but men’s was not.

Before one concludes that the key to making engineering more attractive to young women is emphasizing its potential as a field in which communal goals can be pursued, it is important to acknowledge research that suggests otherwise. Sax et al. (2016) utilized data from the Cooperative Institutional Research Program, a national longitudinal study of U.S. college students housed at the University of California, Los Angeles. This is a very large data set, with more than 8 million respondents between 1971 and 2011. Sax et al. were interested in understanding the changing dynamics of the gender gap in undergraduate majors. Has the gender gap changed, what factors determine men’s and women’s decisions to enter engineering, and have those changed in nature or salience over time? They find a significant increase in women’s interest in engineering since the 1970s, but that that interest remains quite low. Among the factors that predict contemporary women’s interest in engineering, they find that a social activist orientation in engineering has actually decreased in salience, even as women’s interest in the field has increased.

Smith-Doerr, Vardi, and Croissant (2016) conducted an exploratory study of 10 male and 10 female scientists and engineers in 2011 that may help us to understand what is happening. Among the goals of their study was to examine whether it was, in fact, the case that women focused on the social benefits of engineering. They found that neither the men nor the women in their sample were focused on these benefits and that there was no real gender difference on this point. The authors speculate that this may reflect the fact that the women had to adapt to the male norms of science and engineering and that efforts to recruit women to the field by focusing on altruism and social impacts may backfire if young women entering the field find that those aspects are not valued in the workplace.

Stoup and Pierrakos’ (2016) survey of relationships between identity, personalization, authenticity, and persistence differences among four groups of engineering students at James Madison University (29 first-year men, 12 first-year women, 27 senior men, and 14 senior women) points to a similar conclusion. The most significant difference they found was between first-year female and senior female students, with senior women being more introverted. The authors conclude that extroversion increases during an engineering program; this claim would need to be verified with a much larger dataset, however, before it could be generalizable, because this was not a longitudinal study but was rather based on data from different groups of women. Furthermore, in engineering environments, senior women felt the least authentic to their personalities of the four groups (i.e., they felt the most tension and pressure), which could suggest that as women progress through their engineering education programs, they conform to a dominant (male) personality type, even though that is inauthentic to their personalities.

CONFIDENCE AND SELF-DOUBT

Other researchers emphasized that the low numbers of women in engineering may be the result of personal doubts about one’s ability to suc-
ceed in the field. Of particular significance is the fact that these doubts appear not to be related to actual differences in ability or performance. Thus, overcoming them is not simply a matter of helping female students to strengthen their foundational skills in math and science (something that has already been happening for some time).

Seron et al. (2016) note that many entering engineering students (both male and female) have to confront the reality that they are no longer the top student in their cohort; however, women are more likely than men to react to this by doubting their abilities. Ro and Knight (2016) analyzed data from a 2009 survey of 4,901 sophomore, junior, and senior engineering students at 31 four-year institutions in the United States. They found that the women in their study felt that they had lower design skills, although this appeared more related to the pedagogical strategies of instructors than to the actual skills the women possessed. Robnett (2016) studied small samples of girls and women from two high schools, a college, and a graduate program in the western United States. She found that the majority (61 percent) of the respondents reported having experienced gender bias at least once in the previous year, and that this was particularly common in math-intensive fields such as engineering. Robnett also found that this experience of bias was linked to lower STEM self-concept among the women who encountered it, and that this is linked to weaker career aspirations in STEM.

Not everyone is equally convinced that these kinds of self-doubts are the reason for women’s continued underrepresentation in engineering and other math-intensive STEM disciplines. Cheryan et al.’s (2016) meta-analysis of the literature on why some STEM fields are more gender balanced than others found that the existing research has mixed results on this question; they conclude that more research is needed.

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

Cammy R. Abernathy, Ph.D., dean of engineering, University of Florida
Stephanie G. Adams, Ph.D., dean of engineering, Old Dominion University
Emily L. Allen, Ph.D., dean of engineering, California State University, Los Angeles
Nada Marie Anid, Ph.D., dean of engineering and computing sciences, New York Institute of Technology
Nadine N. Aubry, Ph.D., dean of engineering, Northeastern University
M. Katherine Banks, Ph.D., P.E., dean of engineering and vice chancellor, Texas A&M University
Gilda A. Barabinho, Ph.D., dean, The Grove School of Engineering, City College of the City University of New York
Susamma Barua, Ph.D., interim dean, California State University, Fullerton
Gail Baura, Ph.D., director of engineering science, Loyola University Chicago
Stacy G. Birmingham, Ph.D., dean of engineering, Grove City College
Barbara D. Boyan, Ph.D., dean of engineering, Virginia Commonwealth University
Mary C. Boyce, Ph.D., dean of The Fu Foundation School of Engineering and Applied Science, Columbia University
JoAnn Browning, Ph.D., P.E., dean of engineering, The University of Texas at San Antonio
Jenna P. Carpenter, Ph.D., dean of engineering, Campbell University
Emily Carter, Ph.D., dean of engineering, Princeton University
Tina Choe, Ph.D., dean of the Frank R. Seaver College of Science and Engineering, Loyola Marymount University
Robin Coger, Ph.D., dean of engineering, North Carolina A&T State University
Jennifer Sinclair Curtis, Ph.D., dean of engineering, University of California, Davis
Teresa A. Dahlgren, Ph.D., dean, College of Engineering and Computer Science, Syracuse University
Natacha DePaola, Ph.D., dean of engineering, Illinois Institute of Technology
Persis S. Drell, Ph.D., dean of engineering, Stanford University
Doreen D. Edwards, Ph.D., dean, Kate Gleason College of Engineering, Rochester Institute of Technology
Julie R. Ellis, Ph.D., P.E., department head, Western Kentucky University
Jacqueline A. El-Sayed, Ph.D., vice president for academic affairs, Marygrove College
Elizabeth A. Eschenbach, Ph.D., department chair, Humboldt State University
Liesl Folks, Dean of Engineering, Ph.D., University at Buffalo, The State University of New York
Molly M. Gribb, Ph.D., P.E., dean of engineering, University of Wisconsin–Platteville
Christine E. Halley, Ph.D., dean of the College of Science and Engineering, Texas State University, San Marcos
Wendi Beth Heinzelman, Ph.D., dean of engineering, University of Rochester
Martha Hogan, Ph.D., dean of engineering, Richland College
Leah H. Jamesion, Ph.D., dean of engineering, Purdue University
Brig. Gen. Cindy Jebb, Ph.D., dean, Academic Board, U.S. Military Academy
Sharon A. Jones, Ph.D., P.E., dean of the Shiley School of Engineering, University of Portland
Ranu Jung, Ph.D., interim dean, Florida International University
Maria V. Kalenitch, Ph.D., dean of engineering, Robert Morris University
Anette M. Karlsson, Ph.D., dean of engineering, Cleveland State University
Bo-Kyoung Kim, Ph.D., dean of the School of Engineering and Computer Sciences, Daniel Webster College
Debra Larson, Ph.D., P.E., dean of engineering, California Polytechnic State University, San Luis Obispo
Elizabeth Lobo, Ph.D., dean of engineering, University of Missouri
Denise Martinez, Ph.D., department head, Tarleton State University
Charla Miertschin, Ph.D., interim dean, Winona State University
Amy J. Moll, Ph.D., dean of engineering, Boise State University
Holy J. Moore, Ph.D., interim chair, Salt Lake Community College
Jayathi Y. Murthy, Ph.D., dean of the Henry Samueli School of Engineering and Applied Science, University of California, Los Angeles
Hallie Neupert, interim dean of the College of Engineering, Technology, and Management and department chair, Oregon Institute of Technology
Cordelia Ontiveros, Ph.D., P.E., interim dean of the College of Engineering, California State Polytechnic University, Pomona
Elizabeth Orwin, Ph.D., department chair, Harvey Mudd College
Sarah A. Rajala, Ph.D., dean of engineering, Iowa State University
Kristina M. Ropella, Ph.D., Opus Dean, Marquette University
Julia M. Ross, Ph.D., dean, College of Engineering and Information Technology, University of Maryland, Baltimore County
Michelle B. Sabick, Ph.D., dean, Parks College of Engineering, Aviation and Technology, Saint Louis University
Anca I. Sala, Ph.D., dean of engineering, Baker College
Elaine P. Scott, Ph.D., dean of the School of STEM, University of Washington, Bothell
T. Kyle Vanderlick, Ph.D., dean and Thomas E. Golden Professor, Yale University
Sharon L. Wood, Ph.D., P.E., dean of engineering, The University of Texas at Austin
Judy Wornat, Sc.D., dean, College of Engineering, Louisiana State University
Sharon Zeimanowitz, Ph.D., P.E., dean of engineering, U.S. Coast Guard Academy

Courtesy of the American Society for Engineering Education, January 2017

continued on page 16
Sax et al.’s (2016) study of the changing dynamics of the gender gap in undergraduate engineering majors found that, although self-rating of mathematical ability remains a predictor of an interest in pursuing an engineering degree, it has become less salient for women over time. So, it may be that women’s alleged lack of math confidence may turn out to be as temporary as their alleged lack of math ability.

ENGINEERING AS “MASCULINE”

A final explanation of the small numbers of women who are attracted to engineering as a major and career path focuses on the degree to which the field is stereotyped as masculine and/or has a masculine culture. Cheryan et al.’s review of the literature identifies three possible reasons that some STEM fields are more gender balanced than others: gender gaps in self-efficacy in certain fields, insufficient early exposure to certain fields, and the masculine culture of certain fields. As we have just seen, they find that the literature does not yield a consensus on whether women feel less self-efficacy in the fields in which they are underrepresented (math-intensive fields). Cheryan et al. also note that lack of early exposure, per se, does not explain the underrepresentation of women, as there are other subjects in which women are well-represented where early exposure is uncommon (e.g., psychology and nursing). Thus, the masculine culture of engineering, including stereotypes of engineers as socially awkward males who possess innate abilities that women allegedly lack, the perception that women may face bias and discrimination, and the lack of role models in the field, is identified as a significant reason for the low probability that qualified women will select it.

Several studies we reviewed this year found that there continue to be gendered stereotypes of engineers and scientists. It remains the case that Americans perceive these fields as “masculine.” Carli et al. (2016) conducted two small-scale studies of female undergraduates at a small, single-sex liberal arts college and students from a larger coeducational university. They found that respondents generally held stereotypical views of men and scientists as more similar than women and scientists (except for fields such as psychology, where women are well-represented). Female students at single-sex colleges saw more similarities between women and scientists, but, even there, the tendency was to see men and scientists as more similar.

A similar finding emerged from Banchefsky et al.’s (2016) study of 51 U.S.-based workers. Respondents were shown 80 photos (40 of men, 40 of women) of actual tenured and tenure-track faculty in STEM departments at elite universities. They were asked to rate each photo along various dimensions and to indicate the likelihood that each was a scientist. Banchefsky et al. found that respondents used gendered appearance as a cue as to whether the pictured individuals were scientists — women who were rated as “feminine” were perceived as less likely to be scientists, while men’s gendered appearance was not related to the evaluation of their career likelihood.

Stearns et al. (2016) conducted research pointing to the importance of the gender stereotyping of STEM fields. They analyzed data on a sample of 16,300 students who attended any of the 16 colleges in the University of North Carolina system in 2004. Not surprisingly, they found that men were more likely to declare and complete a STEM major. However, they also found that girls who had attended a high school with larger numbers of female math and science teachers were more likely to major in STEM fields. This was true only for white girls; there was no comparable effect for African-Americans. And, the gender composition of the faculty had no measurable effect on boys’ likelihood of declaring and completing a STEM major. Nevertheless, this research suggests that a weakening of the stereotype of a field as masculine (due to the presence of female models) can increase the probability that women will enter fields such as engineering that are typically stereotyped as male.

It is encouraging to note that there has been some effort to combat the stereotypical views of science and engineering that young children have traditionally received. Previs (2016) conducted a content analysis of science stories, letters to the editor, and a feature called “the science corner” published in the popular children’s magazine Highlights between 1967 and 2010. The study found that males were mentioned more than females in science stories, but the discrepancy diminished over time. The “science corner” feature actually tended to feature women more, and females wrote twice as many letters to the editor as males. Over all, the study concluded that Highlights’ portrayal of women in science reflected or even exceeded the real percentages of women in science during the period in question. Previs is not able to determine whether this had any effect on children’s attitudes toward STEM and STEM careers, but it is at least encouraging that a widely read children’s publication did not simply reproduce gender stereotypes of STEM.

It would be premature to conclude that we know, with certainty, why young women, even young women who are capable in math, continue not to be attracted to engineering. However, the research we reviewed this year definitely confirms that engineering continues to struggle to attract young women and that the field remains stereotyped as male.

As it has become increasingly clear that the low numbers of women entering engineering in the first place have little to do with ability, researchers have focused attention, increasingly, on the gendered perception of engineering, and on whether women are able to see themselves in the commonly available images of an engineer.

ARE WOMEN MORE LIKELY TO LEAVE?

Another possible explanation for the under-representation of women in engineering is that some women who begin down the path toward an engineering career change their minds and/or are pushed away from the field. The metaphor of the “leaky pipeline” has frequently been used to characterize what is happening and has been the basis for the argument that increasing the numbers of women in engineering requires attention not just to recruitment but to retention.
Although the leaky pipeline metaphor has been widely adopted, some scholars have questioned whether the evidence supports it. In previous reviews, we drew attention to this lack of consensus; as we noted a number of years ago, Lisa Frehill (2010) (among others) has pointed out that there is remarkably little comparative research on departures from engineering, so it is not entirely clear that women leave the field at higher rates than men. Over the past several years, we have reviewed a number of studies analyzing women’s departure from engineering and STEM more generally; the result, according to this argument, was that at least some capable female engineering students left engineering programs for other, more welcoming academic opportunities.

Some of the research we reviewed this year, however, called this argument into question. Two studies, in particular, presented evidence that women did not leave engineering schools at a higher rate than men. Riegle-Crumb, King, and Moore (2016) analyzed a sample of 3,702 graduates drawn from the 2004/2009 Beginning Postsecondary Students Longitudinal Study. The original study collected data from a larger sample of post-secondary students in 2003 and followed students for an average of six years. In this study, they found that women’s rate of dropout was not statistically different from men’s rate. They also found that women were more likely to pursue a Master’s degree, and that women who pursued STEM fields were more likely to leave engineering for another STEM field.

While the leaky pipeline metaphor has been widely adopted, some scholars have questioned whether the evidence supports it. In previous reviews, we drew attention to this lack of consensus; as we noted a number of years ago, Lisa Frehill (2010) (among others) has pointed out that there is remarkably little comparative research on departures from engineering, so it is not entirely clear that women leave the field at higher rates than men. Over the past several years, we have reviewed a number of studies analyzing women’s departure from engineering and STEM more generally; the result, according to this argument, was that at least some capable female engineering students left engineering programs for other, more welcoming academic opportunities.

Some of the research we reviewed this year, however, called this argument into question. Two studies, in particular, presented evidence that women did not leave engineering schools at a higher rate than men. Riegle-Crumb, King, and Moore (2016) analyzed a sample of 3,702 graduates drawn from the 2004/2009 Beginning Postsecondary Students Longitudinal Study. The original study collected data from a larger sample of post-secondary students in 2003 and followed students for an average of six years. In this study, they found that women’s rate of dropout was not statistically different from men’s rate. They also found that women were more likely to pursue a Master’s degree, and that women who pursued STEM fields were more likely to leave engineering for another STEM field.

Hidden Figures, Rise of the Rocket Girls, and The Glass Universe

The movie Hidden Figures received popular acclaim and three Oscar nominations this year for portraying the lives of African-American women who performed the calculations that sent Americans into orbit and to the moon in the 1960s. The book of the same name, by Margot Lee Shetterly (2016), joined Nathalia Holt’s Rise of the Rocket Girls (2016) and Dava Sobel’s The Glass Universe (2016) in describing the lives of women who worked as human computers in astronomy and the space program. Like the “Top Secret Rosies” of World War II (SWE Magazine, Conference 2013, http://www.nxtbook.com/nxtbooks/swe/conference13/#/36), who calculated ballistic trajectories and programmed the first ENIAC computer, women at the Harvard Observatory, the Langley Aeronautical Laboratory, and the Jet Propulsion Laboratory applied their mathematical skills to classify stars, optimize the designs of air-planes, and determine the orbits of the first spacecraft.

In the late 19th and early 20th centuries, the Harvard Observatory had an ambitious program to photograph and catalog the stars. The director of the laboratory hired a group of women to analyze the photographs, but they did much more than routine, behind-the-scenes analysis. Sobel’s book reveals the existence of a group of mathematically talented, educated women in support of the conclusion that women who enter college-level engineering programs do not leave the field during college at higher rates than men. However, the percentage of women who leave engineering subsequent to earning a degree is higher than the percentage of men who leave, offering support for the view that there is a “leak,” although it appears to be located less in the educational pipeline and more at a stage subsequent to completion of professional training.

There had been some thought in the past that many women left engineering early on, while they were still in school or during the training programs. Most now reject the view that this departure was due to a lack of academic ability (see Wang and Degol 2013, especially pp 307-8, for a review of the literature on this question). The view, however, was that female engineering students were an isolated minority who found few role models among the faculty; that they were likely to encounter a “chilly climate” and to receive less support from faculty and fellow students. The result, according to this argument, was that at least some capable female engineering students left engineering programs for other, more welcoming academic opportunities.

Some of the research we reviewed this year, however, called this argument into question. Two studies, in particular, presented evidence that women did not leave engineering schools at a higher rate than men. Riegle-Crumb, King, and Moore (2016) analyzed a sample of 3,702 graduates drawn from the 2004/2009 Beginning Postsecondary Students Longitudinal Study. The original study collected data from a larger sample of post-secondary students in 2003 and followed them up with them in 2006 and 2009. Riegle-Crumb, King, and Moore examined whether the members of their sample who were in gender-atypical majors were more likely to switch than those who were in gender-typical programs. They found that men in female-dominated fields were more likely to switch than their male counterparts in other majors. However, they found that this was not the case for women in male-dominated fields — they switched at rates similar to their female counterparts in other disciplines. This, of course, leaves open the question of whether women generally are more likely to switch majors than men, but it does suggest that, if women are leaving engineering, it is not because of something unusual about the field. Cheryan et al. (2016) conducted a large-scale study of college students in 2013 and found that women were more likely than men to have switched majors in their first year of college. They also found that women were more likely than men to report that they had been discouraged from pursuing engineering by their high school teachers.

Both books are based on extensive personal interviews. The movie Hidden Figures interwoven with the institutional history of NASA and the cultural evolution of racial and gender relations in the United States. Where Hidden Figures situates its story in the context of the civil rights movement of the 1960s, Rise of the Rocket Girls describes the efforts of JPL’s women computers to balance the work they loved with husbands and children at a time when women could be and were fired when they became pregnant. Some of the Rocket Girls went on to play leading roles in NASA’s planetary program, and Susan G. Finley, who started at JPL in 1958, was still on the job last summer as the Juno probe entered Jupiter’s orbit. All three books document the mathematical abilities of women who lived at a time when the prevailing view was that women’s mathematical skills were inferior. They also reveal the powerful resistance to the inclusion of women as equals in scientific work, even when there was clear evidence that their contributions were invaluable. It is testimony to the remarkable persistence of these women that they achieved what they did; it is also remarkable that their contributions are now only gaining wider acknowledgement as a result of these books and the associated Hidden Figures movie.
ducted a meta-analysis of the literature exploring the question of why certain STEM fields are more gender balanced than others. Their conclusion, based on their review, is unequivocal: "… computer science, engineering, and physics do not have higher attrition of female students than male students between high school and the time they finish college. The current underrepresentation of women and overrepresentation of men in these fields appears to be more of a recruitment issue … than a retention issue." (p. 4)

At least one study continued to offer some support for the view that women leave engineering at higher rates than men, however. Ellis, Fosdick, and Rasmussen reported on data from a survey of a random sample of American calculus I students at two- and four-year colleges, conducted by the Mathematical Association of America in 2010. They found that some calculus I students lose their commitment to continue on to calculus II; standardized math test scores, career intentions (how committed to a STEM career was the student?), and instructor quality all predicted the decision to "switch." Most significantly, the authors found that women were 1.5 times more likely to "switch" than were comparable men. Although there was no evidence that women performed less well in calculus I, women were more likely to say that they did not understand the material in calculus I well enough to continue on to calculus II — hence their reluctance to persist. Ellis, Fosdick, and Rasmussen speculate that this lack of confidence may help to explain why women leave STEM disciplines at higher rates than men.

It should also be noted that there may be other explanations for women's persistence (or failure to persist) in engineering programs. The paper that won the award for Best Diversity Paper at the American Society for Engineering Education (ASEE) Annual Conference was by Yang and Grauer (2016), in which the authors measured the effects of a loan repayment grant on persistence in engineering. They found that when a female student received a student loan repayment grant, it increased their graduation rates (compared with a control group) and increased graduation rates of female students with a wider range of GPAs. While there continues to be some disagreement about whether female students leave engineering programs at higher rates than their male counterparts, there is a higher level of agreement that female engineering graduates are more likely than men to leave the field. The fact that the percentage of working engineers who are female is smaller than the percentage of engineering graduates who are female has often been identified as evidence of this. Several studies we reviewed this year reported this difference as fact. Fouad et al. (2016) reported on their ongoing research on the differences between women who persist and women who leave engineering. In the article they published this year, they note that half of female engineering graduates leave engineering at some point along the way (a higher percentage than for men). Hunt (2016) analyzed data from the 2003 and 2010 National Survey of College Graduates — these are large data sets with more than 100,000 observations, so the survey provides a rich source of information on post-graduate experiences. She found that female graduates are more likely to leave engineering than men, a pattern she did not find for science more generally.

Several possible explanations for women's greater probability of leaving engineering were offered in the research reviewed this year. Seron et al. (2016) conducted a study of engineering students at four New England engineering schools (MIT, Olin, the University of Massachusetts Amherst, and Smith). They described the ways in which students' experiences in engineering school have the effect of weakening some women's commitment to a career in the field. Entering students, whether male or female, typically were top students in high school; now, as engineering students, they have to determine where they are in the pecking order. Seron et al. report that female students are more likely than comparable male students to experience self-doubt when they find out where they are in the hierarchy, which begins to undermine their commitment to the field.

Later in their university careers, students' experiences and various kinds of internships and summer jobs. These turn out to be very different experiences for female and male students, according to Seron et al. Women in teams often find that they wind up managing the team, while men do most of the technical work. Women continue to encounter this kind of gender stereotyping when they enter the engineering workplace as interns or temporary workers. The result is that some women begin to question whether an engineering career will lead to satisfying work. In Seron et al.'s words: "The findings reported here suggest that subtle and cumulative encounters with the values and norms of professional culture compromise women's affiliation with the profession and raise the prospect of departure." (pp. 30-31)

Seron et al.'s analysis builds on earlier work done by one of her co-authors, Erin Cech (2017), who has argued that female engineers sometimes find that their values and self-concept are not fully consistent with the professional identity of an engineer. Other researchers, however, point to different explanations for female engineering graduates' leaving engineering. Fouad et al. (2016) reported, with surprise, that they did not find differences between women engineers who persist and those who depart in either self-confidence or outcome expectations. Rather, they found that the differences between the two groups centered on their experience of workplace support — were they given advancement opportunities and did their managers demonstrate understanding of work/family balance issues. Although Fouad et al.'s analysis does not share Seron et al.'s and Cech's emphasis on self-concept and confidence, both arguments point to the importance of negative workplace experiences and lack of support as factors in female engineers' decision to leave.

SWE undertook a study of why women leave engineering, the results of which were published in the Spring 2016 issue of SWE Magazine. (Holmes, 2016). The study found that women's leaving engineering wasn't primarily the result of work/family balance issues. Instead, women left because they found that they were working in environments that tolerated persistent obstacles to attaining their company and career goals. It was not that women's values were different from men's. Rather, women, more than men, reported finding that highly ranked values were not being met in their workplaces. They noted a lack of "accountability" and were more likely than men to not accept "value breaches," and to become frustrated
when they aren’t given clear, consistent goals and a level playing field. Like Fouad et al., the SWE study draws attention to the role support, opportunity, and positive workplace experiences (or their absence) may be playing in leading some women to leave engineering.

Other researchers do point to work/family conflict as a possible explanation for attrition among female engineering graduates. As we have just seen, Fouad et al. pointed to this as an issue for the engineers they studied. Ecklund and Lincoln (2016) (see sidebar for a summary of this book) made this issue the centerpiece of their analysis of academic science. Although male scientists also experience conflict between their work as academic scientists and their desire to be parents, Ecklund and Lincoln found that this conflict is more intense for female scientists and that they are more likely to consider leaving academic science (or leaving science altogether) as a result. Their analysis focused on biologists and physicists, but it is reasonable to assume that something similar occurs among female engineers in academic settings.

Hunt (2016), however, questioned whether work/family issues are as important as these analyses indicate. Her study of the reasons for women’s departure from science and engineering found that it is not related to the presence of children or to family-related issues. Rather, women are more likely than men to leave engineering for reasons similar to those that explain why women are more likely than men to leave other male-dominated fields, such as economics or financial management. As in these fields, female departures were related to pay and promotion opportunities. Hunt’s conclusion is that “a lack of opportunity, negative experiences at the hands of managers and co-workers, and a lack of support. While one cannot argue that nothing has changed, it is striking that these are problems that would be very familiar to those early computers.

OTHER THEMES
The low numbers of women in engineering were not the only focus of the literature we reviewed this year. Indeed, at the 2016 American Society for Engineering Education (ASEE) Annual Conference, many papers focused on themes we highlighted in last year’s SWE literature review.

Two such papers were new additions to a growing set of work from a group of researchers primarily at The University of Oklahoma who have been studying student engineering competition teams (Pan, Shen, Tytten, Fox, and Walden, 2016; Walden, Fox, Pan, Shenb, and Tytten, 2016). In this year’s paper, Walden et al. presented findings from interviews with 17 faculty members who served as advisors for engineering competition teams (ECTs) for Formula SAE competitions and a Human Powered Vehicle Challenge. The findings from these interviews echo findings presented in 2015, namely that advisors are hands-off and that exclusionary practices related to the teams are not being addressed. Walden and colleagues identified 11 belief categories related to team culture that were grouped into four themes: recruiting, integration, exclusionary practices related to the teams are not being addressed. Walden and colleagues identified 11 belief categories related to team culture that were grouped into four themes: recruiting, integration, ethics of commitment, and lack of diversity. They found that most advisors:

- describe themselves as hands-off and do not actively help new members gain skills or knowledge necessary to be successful on teams
- say that teams are open and welcoming to all but indicate that most participants join because a friend is participating, and new members have to take significant responsibility for finding their own place in the team and “sticking with it”
- believe that if a student deserves to be on the team, they will persevere
- recognize that an “extreme ethos of commitment” is required to participate on teams

• did not discuss race/ethnicity or gender without being prompted, but when prompted, admit that ECTs are “white man’s world”
• demonstrated belief in gender schemas by saying that women don’t like cars and are better at nontechnical leadership positions on teams

No advisors connected the lack of diversity to current recruiting and integration practices, and none described any active efforts to change the demographics of ECTs. Each of these findings supports data from students reported last year. They conclude that advisors do not have the skills or knowledge to promote more inclusive ECTs.

In the second paper by this group, Pan et al. presented findings from a nationwide survey of 116 students from 81 different institutions in the U.S. who had participated in an ECT. The findings supported those presented in 2015 from a survey at one institution, namely that the primary barriers to participation on ECTs are related to:

- Entry (recruitment and integration practices).
- Individuals are expected to overcome entry...
barriers themselves)
• Persistence (structural obstacles such as ineffective processes for enabling new members to contribute, and expectation of extraordinary personal sacrifices, such as high time commitment each week)
• Legacy networks (subordinate members encounter obstacles to participation based on the lack of strong interpersonal relationships with more experienced team members, which becomes an issue when leaders are selected, for example)
• Lack of advisor engagement

Also extending the teamwork theme we first discussed last year was a mixed-methods paper by Wolfe, Powell, Schlisserman, and Kirshon (2016) that examined the problems undergraduate students experienced during teamwork. The survey of 677 students from three different institutions and interviews with 63 students from seven different institutions revealed that women and underrepresented minority (URM) students were significantly more likely than men and non-URM populations to report two problems: dominating teammates and being excluded from the “main work” of the project. Underrepresented minority females in particular experienced more of every type of problem as compared with white or Asian females. Many women and URM students believe that their ideas are given less weight than majority students/men’s and that their exclusion from important parts of the project negatively affected their grades and caused them to leave volunteer teams. The study also asked about how students responded to such problems and found that attempts to discuss the problems with teammates and faculty were often not helpful, and sometimes made the situation worse, resulting in an environment in which students simply decide not to bother informing instructors about problem teammates. They conclude that neither student nor faculty seem to have the resources and knowledge to effectively solve team problems around race and gender.

In addition to the papers on teamwork, there were papers that pressed into the world of intersectional analyses. For example, a work-in-progress paper examined written narratives and discussion of those narratives by eight black women in STEM (Thomas, Watt, Cross, Magruder, Easley, Mone- reau, Phillips, and Benjamin, 2016). This paper identified common experiences of isolation, a lack of support and encouragement, lack of faculty role models, and feelings of obligation to help others or serve as a role model. The authors frame their study through the theory of “womanism” and contend that womanism should be utilized more frequently to theorize the experiences of black women in STEM. Fleming (2016) broke down her data from a questionnaire about success factors for underrepresented minority students to highlight where African-American and Hispanic women differed from other populations in terms of why they chose engineering, the experiences of engineering programs, and their advice for others.

Yet, we also found a notable increase of intersectional papers on topics other than race or ethnicity at ASEE this year. Cech, Waidzunas, and Farrell (2016) explored “Engineering Deans’ Support for LGBTQ Inclusion” through a survey of 47 engineering deans and program directors and found that participants said they were somewhat or very supportive of many LGBTQ inclusion measures. They were not necessarily willing to commit resources to those measures, however, and were generally unsupportive of the most resource-intensive measures, such as hiring initiatives for openly LGBTQ engineering faculty. Participants also believed that their own support for inclusion measures was greater than that of most of their faculty members, which led the authors to conclude that deans may resist inclusion measures because of their perceptions of faculty beliefs rather than their own beliefs. Statistics reported in the paper also led the authors to conclude that deans greatly underestimated the extent of heteronormativity and heterosexism in engineering departments. This is an ongoing project, and the next phase will focus on binary gender schemes in order to allow for greater expression of multiple intersections of gender and sexuality with other social identities (Leyva, Massa, and Battey, 2016). The second is a literature review on identity literature, in which one of several problems identified was that intersectionality is underutilized and undertheorized in the identity literature (Patrick and Borrego, 2016). This literature review also nicely summarizes what is known, and what is not known, about gender and STEM identities, including, importantly, the relationship between identity and persistence, and should be a go-to starting place for researchers wanting to delve into identity research on women in engineering.

Third, recognizing that improved theorizing about non-normative identities requires new data-collection methods, specifically around collection of demographic data, Fernandez et al. (2016) discuss the complexities of collecting demographic data on all types of minority populations and suggest specific strategies and advice for researchers who want to better account for complexities of nuanced identities, including sexual orientation, gender identity, family arrangements, and race/ethnicity, in their data collection.

Lastly, in a fourth paper that is part of an ongoing, mixed-methods project, that same group of researchers demonstrates how they are utilizing new data collection and data analysis techniques to advance understandings of non-normative identities in engineering (Kim et al., 2016). It is worth noting that while they did not specifically set out to study teamwork, the qualitative data presented in this paper relates back to the teamwork theme discussed above by highlighting that problems women encounter often occurred in the context of teamwork.

Aside from these ASEE papers, however, we found only one journal article on LGBTQ issues. In 2015, Yoder and Matthis (2016) surveyed 1,427 LGBTQ individuals who were working in STEM fields in both academia and industry (21 percent were from engineering). The research found that respondents were more open in their personal than in their professional lives, but that there was a positive correlation between the percentage of women in the field and levels of openness in professional life. Those who reported a high degree of openness in the workplace also were more likely to describe their workplace as safe and welcoming and to have positive things to say about their employers’ support for LGBTQ needs. The study found more positive experiences...
than previous research on these issues; the authors note, however, that they may be missing negative experiences among those who chose to leave the STEM pipeline.

Several ASEE papers also contributed new data to last year’s discussion of sexual harassment and also broke down data by underrepresented minority (URM) students (Fitzpatrick, Romero, and Sheridan, 2016). Items on harassment and stereotyping were added to a climate survey of one college of engineering that included 733 men and 237 women, of which 45 were URM, in 2008; and 714 men and 287 women, of which 70 were URM, in 2015. In 2008, women reported significantly higher rates of stereotyping and harassment (such as being singled out in class, faculty expressing stereotypes, and sexual harassment from other students) than men reported, and URM students reported higher rates of racial stereotyping and harassment than majority students reported. In 2015, more than 38 percent of students reported hearing other students express gender stereotypes, and 37 percent of students reported hearing other students express racial stereotypes, 58 percent of women reported hearing other students express gender stereotypes, and 55 percent of URM students reported hearing other students express racial stereotypes.

Further, two troubling findings related to changes over time were that in 2015 professors, student interactions, and engineering self-efficacy were all rated significantly lower than they were in 2008, and that of the six stereotyping/harassment items included in both years, four items were endorsed by significantly more students in 2015 than in 2008. Those items were: singled out because of race, faculty express stereotypes, and students express race stereotypes, singled out because of gender, faculty express gender stereotypes. However, two items (sexually harassed by faculty, and sexually harassed by other students) were endorsed at lower rates in 2015. These findings raise questions about whether some problems are occurring at last year’s discussion of sexual harassment, or whether they are being “seen” and reported at higher rates. If the former, this study would undermine the oft-heard assertion that gender biases are slowly going away and will continue to decrease as the older generations of men retire.

Furthermore, evidence of harassment was found in a study about workplaces climates. Yonemura and Wilson (2016) also concluded that men do not experience negative work environments in the same ways as women do, or evaluate negative work experiences by the same criteria as women (based on interviews with 16 male and 29 female computer science graduates). Sixty-nine percent of women discussed some aspect of a hostile work culture, including discrimination and harassment. And, in a related survey of female STEM faculty intended to measure subtle gender biases and microaggressions (Yang and Carroll, 2016), 25 percent of the participants had experienced stereotypes of women or were objectified on their physical appearance, 40 percent had been either ignored in a professional setting or had been challenged regarding their authority, 25 percent had been told women’s work would be inferior to men’s work, or told they were “too assertive or sassy.” Differences were found based on rank, position, age, and ethnicity, and the authors conclude that further research is needed to sort out differences among departments and other contexts.

**WHAT CAN BE DONE?**

As we indicated at the outset of this review, popular books and films such as *The Glass Universe* (2016) and *Hidden Figures* (2016) remind us that women played an important role in engineering and science even when they were more or less invisible participants in the STEM workforce. They also put contemporary engineering and science in context—it is obvious that things have indeed changed, at least to a degree. The scholarly literature we reviewed suggests that the amount of progress toward the full gender integration of engineering and science has been limited. It also reveals the multiple forces that make this integration so difficult and draws attention to the many things that need to happen if gender equality in these fields is to be achieved.

Although scholarly researchers have revealed significant obstacles to the gender integration of engineering and science, they also have described things that have worked, or have the potential to work. Readers of this literature learn that some of the factors that have been identified as obstacles to increasing the numbers of women in engineering can be overcome, with appropriate effort, resources, and commitment. A review of the literature is, thus, simultaneously an experience of frustration at the limited progress and optimism that change is at least possible.

As noted earlier, some researchers have found that women are not attracted to engineering, or leave the field after entering it, because they have doubts about their ability to succeed. However, Ro and Knight (2016) present evidence that pedagogical choices can have a positive influence on women’s evaluation of their own abilities and potential. While women in their study typically reported that they had lower design skills than men—whether or not this was actually the case—women who described having instructors who used more student-centered teaching methods and who experienced a stronger emphasis on professional skills in their coursework reported higher design skills. Thus, simple changes in pedagogical approach can increase the chances that women will enter and/or stay in the field. However, these findings must be considered in light of other research reported last year and below that shows how teamwork is often a site for the manifestation of gender bias, and any pedagogical choice should be made with an effort to ensure equality, not an assumption that it exists.

Ro and Knight also found that women who participated in nonengineering co-curricular activities reported having greater fundamental skills, contextual competence, and communication skills. They conclude that this likely reflects the benefits of having found support from other women in their engineering careers. Ecklund and Lincoln (2016), in their study of academic science, emphasize that this can (indeed must) be addressed by policies that move society away from the idea that a scientist (or engineer) must be an “ideal worker” who puts work before everything and is willing and able to delegate their family responsibilities to a partner at home. In academic science, this means providing on-site day care, providing better child care benefits, and making leaves and tenure clock stoppages automatic, not something that requires special permission. While the policies needed outside the academy might take different forms, one of Ecklund and Lincoln’s central arguments would appear to apply to a wide range of employment contexts: The policies cannot be available only to women. They argue that such policies must apply universally both because increasing numbers of men are dissatisfied with work-family conflict and also because scientific careers because they prevent them from devoting the time they would like to family and because, if the opportunities are only for women, they will not gain the broad, cultural acceptance that is needed to allow individuals to take advantage of them.

The progress of women in academic engineering has been greatly aided by the efforts of the various ADVANCE programs funded by the National Science Foundation. Two articles we reviewed this year reported on what has been accomplished at individual universities that participated in the program. Steng-Norris and Kerrissey (2016) reported on the effects of the ADVANCE program funded by the University of California, Irvine, the first such program in the California system and one of the earlier programs funded by NSF. They note that the university opted to support the program beyond STEM fields, indicating a high level of institutional commitment. They found that the program had resulted in a significant increase in the percentage of female faculty, an increase that was greater at Irvine than at other comparable public institutions in the state. However, they found that the effect of the program had primarily been on hiring, not retention (where Irvine actually had below average results for the state system). They concluded that this was largely because the focus of the program was on the recruitment process; in that sense, Irvine’s program successfully achieved what it had set out to do.

Stewart, Malley, and Herzog (2016) described the results of another early ADVANCE program, this one at the University of Michigan. They found that the effects of the program varied by...
department. Some departments experienced substantial change, others some change, and several experienced little or no change at all. What accounted for the different outcomes? The authors found that change was enabled when there was strong leadership supporting the change, when the disciplinary context was favorable, and when the department had a negative past experience or experiences that could be used to mobilize support for positive change. In departments where issues besides diversity were viewed as more important and/or where the context was unfavorable, efforts to change were more likely to fail.

These experiences from the academic world demonstrate that it is possible to move the gender “needle” if an organized, well-funded effort to do so is put in place. Nothing is guaranteed, of course, as the unsuccessful aspects of these programs demonstrate. With strong leadership and a willingness to make change a priority, however, much has been and can be accomplished. It would be interesting indeed to see what would be the results of a program like ADVANCE outside the context of academic engineering and science.

Researchers who focus on the issue of creating gender integration in engineering continue to emphasize the importance of moving beyond an approach that involves “fixing the women,” of requiring them to adapt to institutional arrangements designed for a largely male workforce. They contend that increasing the numbers of women in engineering requires engineering to change — to become less obviously gendered in all sorts of ways. At the same time, one of the more interesting findings in the research we reviewed this year is that women’s departure from engineering careers is linked not just to the differences between women and men but also to their similarities. As the SWE study of why women leave engineering found, women, like men, want to be given opportunities, to be supported, and to find that they are able to pursue the goals and objectives their workplaces say they are supposed to pursue.

A review of this year’s scholarly literature on women in engineering, therefore, leaves one with a sense that there is a dual project to be completed. On the one hand, engineering needs to become less gendered and to move in directions that make it both more consistent with women’s goals and objectives and more accommodating of their needs and concerns. On the other hand, whether or not it becomes less gendered, engineering must treat men and women the same — provide all with opportunities for advancement and support. Progress on either of these fronts would certainly improve matters. But, it is likely that full gender integration of engineering requires progress on both.

Finally, as we reflect on the competing and sometimes contradictory findings from this year’s literature, we wish to reiterate one of our suggestions for future research from last year: meta-analyses that look across disciplines to make sense of conflicting findings and provide grounds for moving forward to advance research. Given the wide range of methods, populations, sampling, and analysis techniques in the literature, critical meta-analyses, or systematic reviews, could help make sense of the lack of consensus we continue to see around key questions that arise year after year. The lack of consensus is also a good reminder to be cautious of making claims about “women” in engineering as a homogenous group who all share the same values, goals, and beliefs.

About the authors

Peter Meiksins is vice provost for academic programs and professor of sociology at Cleveland State University. He received his B.A. from Columbia University and his Ph.D. from York University, Toronto. Major publications include Putting Work in Its Place: A Quiet Revolution, with Peter Whalley (2002), and Changing Contours of Work: Jobs and Opportunities in the New Economy, third edition, with Stephen Sweet (2016). He is a member of the editorial advisory board of Engineering Studies.

Peggy Layne, P.E., F.SWE, is assistant provost for faculty development at Virginia Tech. She holds degrees in environmental and water resources engineering and science and technology studies. Layne is the editor of Women in Engineering: Pioneers and Trailblazers and Women in Engineering: Professional Life (ASCE Press 2009). A Fellow of the Society of Women Engineers, Layne served as SWE FY07 president.

Kacey Beddoes is an assistant professor of sociology at the University of Massachusetts Lowell. She holds a Ph.D. in science and technology studies and graduate certificates in women’s and gender studies and engineering education from Virginia Tech. Beddoes serves as managing editor of Engineering Studies. Her current research interests include gender in engineering education research, interdisciplinarity, peer review, engineers’ epistemologies, and global engineering education.

Sarah Masters is a Ph.D. student in the engineering education department at Virginia Tech, where she studies issues of equity and social justice in engineering with particular attention to the experiences of women and LGBTQ+ engineering students. Masters has served as a SWE counselor twice and is a recipient of the Ada I. Pressman Memorial Scholarship.

Micah Roediger is a doctoral candidate in industrial and organizational psychology at Virginia Tech. His research focuses on quantitative methods and construct measurement.

Yashna Shah is a doctoral candidate in industrial and organizational psychology at Virginia Tech. Her research focuses on gender and leadership, specifically the impact of role models on women’s leadership behaviors, perceptions of male and female leaders, leader identity, and measurement of implicit leader-theory biases.

References

The following comprise all of the noteworthy articles and conference papers found in our search of the 2016 literature on women in engineering. We selected for discussion in our review the literature that seemed to be based on the most substantial research and/or that offered interesting, fresh insights into the situation of women in engineering. For reader’s convenience we have included the complete list of materials we consulted.


Riegel-Crumb, C., B. King, and C. Moore (2016). "Do They Stay or Do They Go? The Switching Decisions of Individuals Who Enter Gender Atypical College Majors." Sex Roles 74(9): 436–49.


Better science, innovation, and discovery are the outcomes of a gender–responsible approach to research — as the power of sex and gender analysis brings knowledge and insights that would otherwise be overlooked.

By Sandra Guy, SWE Contributor
Londa Schiebinger, Ph.D., seeks out engineers, researchers, and scientists worldwide to innovate with an eye toward gender. The John L. Hinds Professor of History of Science at Stanford University, Dr. Schiebinger leads gendered innovation breakthroughs as director of the European Union/United States Gendered Innovations in Science, Health and Medicine, Engineering, and Environment Project.

“Gendered innovation is about looking for solutions,” she said. “Can we redesign the world for both men and women in terms of equality — and for gender equity?” That's how Dr. Schiebinger and her colleagues scrutinize the relationship between elderly people and robots that are being developed to help them stay at home rather than move to an assisted living institution, for example.

Robot designers need to take gender preferences into account — of both men and women — for the more intimate chores that robots will eventually do, such as helping those who need assistance to bathe and dress, she said. “The designers need to make sure, as these machines come online, that they work equally wonderfully for both men and women. And the robots are coming.”

Dr. Schiebinger said she believes that as more women gain science, technology, engineering, and mathematics (STEM) degrees and careers, they will influence future innovations. “It seems to me, if more women got into these fields, we’d have more domestic robots,” she said. “I’m waiting for one that will be fabulous.”

“My first books were about the making of human knowledge — what went wrong. How is knowledge biased? First, it is important to define the problem,” she said. “When I coined the term ‘gendered innovations’ about (the year) 2005, I realized that we needed to refocus the discussion from gender bias to gendered innovations,” Dr. Schiebinger added. “I wanted to fire people’s positive imaginations. I wanted to find solutions. I was really interested in how we can make things better.”

When Dr. Schiebinger started the Gendered Innovations in Science, Health and Medicine, Engineering, and Environment Project in 2009, she wanted to attract engineers, scientists, gender experts, and innovators from throughout the world. “So I had to consider, ‘What’s in it for them?’ What new discoveries can they make if they use gender analysis?”

The project (http://genderedinnovations.stanford.edu/) won funding in January 2011 from the European Commission, which set up an expert group, “Innovation through Gender,” aimed at developing the gender dimension in EU research and innovation. The U.S. National Science Foundation joined the project in January 2012. Stanford University also helps support the project, which harnesses the creative power of sex and gender analysis for innovation and discovery.

The project now involves more than 80 experts from across Europe, Asia, Canada, and the United States. Gendered Innovations played a role in developing the 2010 genSET Consensus Report that called for gender equality in science in four key areas:

- science knowledge making
- deployment of human capital
- institutional practices and processes
- regulation and compliance with gender-related processes and practices

genSET aims to improve European science by including a gender dimension in research and science knowledge making.

Gendered Innovations has also made its way into a March 2011 United Nations resolution calling for compiling and sharing good practice examples and lessons learned in mainstreaming “a gender perspective into science, technology and innovation policies and programmes, with a view to replicating and scaling up successes.”

Even more importantly, Gendered Innovations case studies served as evidence for the concept of the “gender dimension” for European Commission funding policy, Dr. Schiebinger said.

Since 2013, the European Commission has asked researchers to integrate sex and gender analysis into their research when they seek funding. The new perspective aims to expand the three approaches to gender equality that governments, universities, and, increasingly, corporations in the United States and Western Europe have taken over the past several decades:

A Case Study

Another case study involving the medical field looked at the effects of using all female cells and tissues in stem cell therapies. Why might the sex of the cell be relevant? Research shows that the therapeutic capacity of male and female stem cells differ, Dr. Schiebinger said.

Yet few researchers consider the sex of their cells when doing experiments — which can lead to failed research, she said. For example, an international research team from Norway and Australia worked with stem cells in mice. They appropriately used male and female mice (using both sexes in basic research is excellent design). However, they used all female stem cells — this was an unconscious and arbitrary decision. Unfortunately, it also meant that, by the very nature of the way the experiments were performed, they did not see anything unique to male stem cells. Nor did they detect important differences in function between male and female cells.

The result of not considering the sex of the stem cells was that their male mice died — and they didn’t know why, Dr. Schiebinger said. Eventually, through a Gendered Innovations workshop in Norway, the team realized they should consider the sex of the stem cells, Dr. Schiebinger said.

In this case, they found that sex-matching of donor and recipient yielded the best result — but the result shouldn’t be taken for granted for all research going forward, she said. That’s because all combinations of donor/recipient interaction should be tested before being ruled out; there are many factors that interact with sex, and it’s important to analyze these factors during an experiment, she said. In the case of stem cells, these factors may include cell type; disease being treated; and other hormonal, immunological, and environmental factors.
“Women Still Do a Good Share of the Domestic Work Around the House. If We Could Automate These Things to Free People from Domestic Burdens, This Would Be Fabulous.”
— Londa Schiebinger, Ph.D., John L. Hinds Professor of History of Science at Stanford University

MOVING BEYOND PINK AND BLUE

Dr. Schiebinger, a native of Lincoln, Nebraska, started college as an English major. She said she appreciated getting an excellent, affordable education at the state’s land-grant institution, the University of Nebraska.

Her success prompted some of her professors to encourage her to leave the state and experience the wider world. While teaching piano lessons in Europe, she said she was thrilled to discover one could “make a living by reading books and learning cool things.”

In graduate school at Harvard University, Dr. Schiebinger switched her focus to intellectual history, and later, the history of science.

While pursuing her Ph.D. in the late 1970s, Dr. Schiebinger noticed there were extremely few women faculty. “The course work said nothing about families, marriage, birthing — those important parts of the human experience,” she said. “I got interested in why more women weren’t involved in intellectual endeavors, especially in science.”

She realized she could research the situation from a cultural point of view. So after earning her Ph.D. in history from Harvard in 1984, she joined the move to attract more women to science and engineering. “As a historian, I thought, ‘I have something valuable to contribute,’” she said. Dr. Schiebinger takes an expansive view of the situation. “Gender analysis involves a set of analytical skills that can be learned. Engineers and basic scientists are now beginning to understand how to integrate gender analysis into their work — as one variable among many.

And we are working on incorporating this perspective systematically into university curriculum.”

Indeed, Stanford offered a course on diversity in the school of engineering last year and has now set up a faculty college — an interdisciplinary group of some 16 professors and staff — to explore ways to integrate a basic understanding of gender into the engineering curriculum, computer science, and other basic sciences where it would be relevant, she said. Stanford’s design school launched a new course this spring called “Beyond Pink and Blue: Gender in Tech” that will team up with companies to revolutionize product design.

“We at Stanford want to provide the best graduates possible for companies in Silicon Valley and across the United States,” Dr. Schiebinger said.

GENDER–RESPONSIBLE SCIENCE AND TECHNOLOGY

Dr. Schiebinger foresees progress in another area — biomedical science — in part because, as of Jan. 1, 2016, the National Institutes of Health started requiring that sex be analyzed as a biological variable in public-funded research, where relevant.

Why are sex and gender analysis important? Doing research wrong costs lives and money, Dr. Schiebinger said. For example, between 1997 and 2000, 10 drugs were withdrawn from the U.S. market because of life-threatening health effects, according to a report by the Government Accountability Office, which acts as a government watchdog.

Addressing this in her blog, Dr. Schiebinger wrote: “Eight of these posed greater health risks for women than for men. Not only does developing a drug in the current market cost billions — but when drugs fail, they cause human suffering and death. Doing research right has the potential to save lives and money. A 2014 analysis of the U.S. Women’s Health Initiative Hormone Therapy Trial, for example, found that the study saved lives. Reduced use of estrogen plus progestin hormone therapy resulted in 76,000 fewer cases of cardiovascular disease; 126,000 fewer breast cancers; and 145,000 more quality-adjusted life years. While most of the results were positive, the analysis of breast cancer risks was controversial. The overall economic savings to the U.S. healthcare system was $35.2 billion (or $140 per $1 invested in the trial).” (http://blog.addgene.org/gendered-innovations-why-does-sex-of-the-cell-matter)

Because of such findings, Gendered Innovations aims to get the research right from the beginning. Dr. Schiebinger said. To do so, the project: develops state-of-the-art methods of sex and gender analysis; and provides case studies with concrete examples of how gender analysis leads to discovery and innovation.

Much work needs to be done, but progress is ramping up, Dr. Schiebinger said. Researchers are developing sophisticated methods of sex and gender analysis. Universities are working to incorporate these methods into their curricula. Corporations are building these new insights into products. Eyes have been opened — and we cannot return to a world that ignores gender. ▶️
At the Intersection of Gender, Engineering, and Sustainability

The London transportation system — a seemingly mundane infrastructure of trains, buses, and the Underground rapid transit — shows how unconscious gender bias heightens women’s struggles, says a prominent engineering diversity and sustainability advocate. The transit system’s design is prioritized around a quick shuttling of workers to the paid labor force in and out of the city’s center.

“As we still have gendered patterns of employment, with more women than men undertaking unpaid, local caring responsibilities and men traveling to work in the city center, we see that the transit system is optimized for the male experience,” said Ellie Cosgrave, Ph.D., deputy director at the University College London’s City Leadership Laboratory and a UCL lecturer in urban innovation and policy. That’s because women — many with children, groceries, and work gear in tow, and whose daily schedules require hopping on and off the Underground to run errands — must accommodate the train system’s design, rather than the transit system accommodating them, Dr. Cosgrave says. “We need to look back at the engineering design process to see how to meet the needs of various groups in the future,” she said.

Indeed, she is heartened that gender is increasingly being recognized as an issue in such design. She has started a yearlong study to deconstruct an infrastructure project’s life cycle to better understand the gender orientation, improve access, and link the outcome to promoting sustainability.

The Underground train system also has huge personal meaning because it’s where Dr. Cosgrave was sexually assaulted in 2012, and where, a year later, she danced in protest to reclaim the train for women. A story in The Guardian newspaper detailed how on March 8, 2013 — International Women’s Day — Dr. Cosgrave held a sign explaining what had happened to her, and took back her right to ride the train in peace and safety.

“I danced my protest, and it felt right,” Dr. Cosgrave said in the article. “It was petrifying, exhilarating, and soothing all at once, and it was absolutely fitting.” See https://www.theguardian.com/life-andstyle/thewomens-blog-with-jane-martenson/2013/mar/08/woman-sexual-harassment-international-womens-day

“I’m grateful for the people that came to share their own stories, who expressed their anger, and who asked me what we can do to make real change,” the article quoted Dr. Cosgrave. “Online, I was inundated with stories that were unbelievably similar to my own. Women in New York, Paris, and all over the world who were standing up and shouting about what had happened to them.”

“Women shouldn’t have to live like that, dealing with a level of anxiety that men don’t feel,” she said in a Feb. 7 interview. Indeed, Dr. Cosgrave says she is still frustrated by the long-standing “girl” stereotype being “prissy, nice, kind, sensitive, and pretty” as juxtaposed to the stereotype of science and engineering as loud, blowing up things, and being hyperaggressive. “These stereotypes don’t go together — girls doing science — yet they are wholly socially constructed and false,” she said.

The enduring stereotypes play out in how teachers focus on the technical aspects of engineering, while students feel motivated by issues such as sustainability and making the world a better place — passions Dr. Cosgrave cites as a key reason she went into the engineering profession. That gap needs to be bridged, too, she said.

In a paper titled “Towards a Gender Lens in (Civil) Engineering for Cities,” co-authored with colleague Tiffany Lam, the two write, “We argue for a transition from the current state of engineering education and professional practice to a more social justice oriented approach that incorporates a gender lens that values women’s experiences in order to build more inclusive cities.”

Dr. Cosgrave also channeled her frustrations with fighting to be seen as “one of the boys” while still being patronized at work, into claiming her own voice online. She is co-director of Science Grrl, an online network of people who celebrate and support girls and women in STEM fields. Dr. Cosgrave posted a story about the success of a 50:50 rule that saw the number of girls quickly jump ahead of boys who attend the University College London engineering department’s education programs.

“By demanding 50:50, UCL were able to create a step change in the representation of female students on their courses — and it happened almost overnight,” Dr. Cosgrave wrote. “This shift has been extraordinarily effective but change is never easy. Demand 50:50 has required a resilience and dedication from the team delivering the new policy.”

Noting the key relationship between sustainable infrastructure and gender equity, Dr. Cosgrave sees hope in the activism that is taking place in the United States and parts of Europe. “There’s a feeling of solidarity — an increasing unity between people fighting for social and racial justice and between feminists and climate change advocates,” she said.
A Deeper Look at Gender and Racial Bias

SWE’s recent study, “Climate Control: Gender and Racial Bias in Engineering,” quantifies the experiences of underrepresented groups and unearths a wealth of firsthand information about how implicit bias plays out in the profession.

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

Much research has been conducted on why there continue to be relatively small numbers of women in engineering. Of this large body of work, a significant portion has focused on why individuals who have invested so much time and energy into obtaining an engineering degree choose employment outside the profession, either immediately upon graduation, or early in their careers. Is it the stereotypes that society promotes around math and science? Is it that engineering is viewed as too masculine a field for a woman? Is it the culture of the engineering college that makes being in the minority too uncomfortable to stay? Is it that women and underrepresented minorities are not viewed equally in certain hiring and promotion decisions? And what role does the overall workplace culture — including the dynamics of teams — play in retention?

Answers and solutions may be found through continued investigation of all these factors. The Society of Women Engineers has been working for more than 60 years to address the inequities in engineering, and SWE continues to try to understand and tackle the causes of these inequalities. Recently, SWE partnered with Joan C. Williams, J.D., a Distinguished Professor of Law and the director of the Center for WorkLife Law at the University of California, Hastings College of the Law, to conduct a study of unconscious bias in engineering. The study involved surveying male and female engineers to determine whether unconscious gender and racial bias exist in the workplace.

WHAT IS UNCONSCIOUS BIAS?

The unconscious biases that we have about others — those who don’t look like us or come from backgrounds that are not like our own — can affect how we interact with them. We make thousands of decisions a day, and there are so many ways that our decisions can be influenced by assumptions we make about the individuals we encounter, without really questioning or being aware of those assumptions, let alone examining them. No matter how open-minded and objective we believe we are, our views of others are affected by our beliefs, values, culture, and experiences. Our behavior and decision-making are influenced by these same factors.

The impact of unconscious gender bias in the workplace is highlighted by a recent study in the science, technology, engineering, and math (STEM) fields. Using a double-blind, randomized design, STEM professors from research-intensive universities were asked to rate the application materials of students for a laboratory manager position. The applications were randomly assigned male or female names, but the qualifications were identical. Researchers discovered that both male and female professors rated male applicants higher than female applicants and were willing to offer a higher starting salary and more career mentoring to male applicants. The conclusion was that pre-existing unconscious biases against women played a role in the reviews, resulting in less support for female students.

Similar unconscious biases exist with respect to race. A study conducted in 2004 found that applicants with African-American-sounding names were 50 percent less likely to receive callbacks for interviews when applying to help-wanted advertisements than those with white-sounding names. Another study found that white employees were believed more competent and were held to less-stringent standards of competence than African-American employees. These biases are real, and they have a real impact on the livelihoods of everyday people. Recognizing that we each hold such subtle biases is the first step toward addressing the effects those biases have in education and the workplace.

UNCONSCIOUS BIAS IN THE ENGINEERING WORKPLACE

Does unconscious bias exist in the engineering workplace? To answer this question, SWE conducted a survey. The approach was simple: Ask engineers what they have experienced personally in their careers and compare the responses of women and engineers of color to the responses of white men (the majority group in engineering). Engineers from across all disciplines and industries were invited to participate.

The study focused on four basic patterns of bias:

• **Tug of War** involves the competition that can exist between women in organizations. For those in male-dominated professions, this bias can manifest itself as a fight for the “woman’s spot.”

• **Prove-It-Again** centers on the need to prove yourself over and over, despite past achievements and level of expertise. Prior studies on unconscious bias have shown that this bias exists based on both gender and race, requiring women and people of color to work twice as hard to be seen as equally competent to a white male. This bias has also been documented in other areas, including age, sexual orientation, and disability status.

• ** Tightrope** describes the need to behave in masculine ways to be perceived as competent, while still being expected to maintain your femininity. Those who experience this bias “walk a tightrope” between being seen as too feminine to be competent and too masculine to be likeable.

• **Maternal Wall** concerns the biases that are held against women with children. In some cases, their commitment and competence are questioned, and they are denied access to opportunities that women without children, and men (regardless of whether they have children), are offered.

**METHODOLOGY**

Using the Workplace Experiences Survey developed by Joan Williams and employed in past studies of bias in other professions, we received more than 3,000 responses to our calls for participation in early 2016. SWE reached out to potential participants through social media, and with assistance from other associations, to gain a representative sample. Engineers with at least two years of experience as an engineer were eligible to participate. All responses were obtained anonymously.

After ensuring eligibility, demographic data on gender, race, industry, and position were collected. The body of the survey consisted of 39 Likert scale questions (strongly disagree to strongly agree). Most were categorized under the four bias types, but select questions were also asked to gain an understanding of the influence of unconscious bias in workplace processes. We analyzed the survey data using univariate, bivariate, and multivariate statistical techniques to allow for comparisons among
various demographic characteristics, including gender and race.

In addition to the quantitative data collected, the survey included a single text field for optional comments. Approximately one out of every three survey respondents left comments, which was significantly more than expected. The comments collected in the survey, as well as the data collected through 11 interviews conducted with female engineers in the spring of 2016, were analyzed and categorized, providing a rich collection of examples to support the quantitative findings.

RESULTS

What became clear after much analysis was that our findings not only support the existing research on gender and racial bias in the workplace; they provide a much clearer picture of how these biases reveal themselves in everyday workplace interactions and processes. Stereotypes exist about what an engineer looks like, whether by gender, race, or age — and these stereotypes can and do affect the trajectory of an engineer’s career when those assumptions are the basis for the attitudes, behaviors, and decisions that co-workers, managers, and customers make daily. The results from our study offer real-world examples of what engineers are experiencing in the field, highlighting the impact of the obstacles and challenges they encounter as a result of unconscious bias.

The findings of the study show how responses from those underrepresented in the profession, specifically women and engineers of color, compare against responses from white male engineers. This comparison is made to illustrate how workplace experiences of those within minority groups in engineering (based on race and gender) vary greatly from the experiences of engineers within the majority group.

PROVE-IT-AGAIN

“Women have to look more professional and demonstrate technical prowess at all times to receive the same respect as a male engineer who is just an average engineer.” – White female aerospace engineer

In response to questions focused on behaviors categorized under the Prove-It-Again bias, women were much more likely to indicate the existence of a double standard than were male respondents. Almost twice as many women as men indicated feeling that they have to repeatedly prove themselves to earn the same level of respect and recognition as their male colleagues. Women also reported having their ideas stolen or overlooked more often than men. These same biases were found across race as well (Figure 1).

“I have learned that I never have the benefit of the doubt ... and must make for myself opportunities which are given to others.” – White female mechanical engineer

“Men are right, [and] women need to justify and continually argue their point/position/recommendation. ... This is the root issue I see in the workplace for women.” – White female computer scientist

Some respondents indicated that the behaviors associated with this bias pattern have had a negative impact on their careers. Engineers of color, regardless of gender, reported that they often feel left out of the “boys’ club,” affecting their access to promotions and other career advancement opportunities.

“As all project managers and higher-ups in my company are males, the males tend to talk about ‘male’ things together and therefore the males get more opportunities as they arise.” – Hispanic/Asian-American female civil engineer

“A man’s gotta golf,” quote from my manager after gathering the male engineers from my meeting so they could tee off at 2:00 pm.” – White female electrical engineer

The stereotypes that exist showed themselves in multiple ways in this study (Figure 2), but one of the most overt was in the percentage of respon-
dents who indicated that they are often mistaken for administrative or custodial staff.

“I am now a project manager and a professional engineer, but people regularly tell me that they want to talk to the ‘real engineer’ and are very surprised to find out that I ‘am’ a ‘real engineer because they were expecting a man.” – White female civil engineer

“I don’t know if it’s because I am a young female engineer, but I am consistently having to correct people that I am not a secretary or a procurement agent (buyer). I also feel like I have to prove myself and my technical skills more.” – White female aerospace engineer

Because engineering is a field dominated by white men, female engineers and engineers of color who had entered project management or business roles were more likely than their white male counterparts to report feeling that they were seen as lacking the technical skills expected of engineers.

“Even in a leadership role, my male colleagues will still ignore my knowledge or guidance on a routine basis, preferring to seek guidance from other male colleagues.” – Hispanic female electrical engineer

The Tightrope bias presents a unique challenge for those whose behavior is not in line with how people believe they should behave. For example, assertiveness in a man is admirable, but in a woman, it can be seen as aggressive. Responses to Tightrope bias questions in the survey indicated that female engineers and engineers of color were less likely to be given access to desirable assignments or high-profile tasks than their white male colleagues (Figure 3). Access, or lack thereof, can have a significant impact on an engineer’s career trajectory.

“You can’t advance or get a raise if the managers don’t give you projects to prove yourself on.” – White female engineer

Female engineers and engineers of color were more likely to report that they do not feel they can behave assertively or freely express anger at work, compared with white male engineers in this study. In some cases, survey respondents reported having received pushback or backlash for displaying such behavior (Figure 4).

“…I have heard that I am considered argumentative or aggressive, even though I don’t do anything different than my male counterparts.” – Hispanic female electrical engineer

“Moving from being seen as a male engineer to a female engineer has been rather eye-opening … I feel like I get talked over, and have to be more polite in meetings, and let others take the lead, being interrupted in meetings, and being assigned office housework tasks more often than male engineers (Figure 5).”

“I had my white male counterpart engineers who were being given the opportunity to present papers (at a conference). My boss wanted me to write those papers for them, but didn’t want me to go to the conference to present.” – African-American female engineer

“I was specifically asked to get coffee in the middle of my presentation during one event.” – Hispanic female electrical engineer

Prior studies of the Tightrope bias have typically centered on gender, but this study found that the Tightrope bias exists in the engineering workplace for people of color as well. Engineers who are not given access to desirable assignments, who are treated as administrative staff, and who encounter pushback when behaving assertively at work will have a harder time reaching senior-level positions than those who are valued for their assertiveness, are treated as professionals, and are offered high-profile tasks.

**MATERNAL WALL**

“After having children … the principals in my office … automatically assumed that my career wasn’t as important (relative to my male counterparts, with...
or without children).” – Asian-American female civil engineer

Interestingly, a number of female survey respondents indicated that they had not experienced gender bias until they had children. The Maternal Wall bias is figuratively a barrier that can appear after having kids, including that “mothers belong at home raising their children” and “a woman with a child would not want to travel.” Research around this particular bias pattern has found that women with children are less likely to be hired, less likely to be promoted, and rated lower salaries than women without children. Mothers also face more work at home when having kids, including that “mothers belong at home raising their children” and “a woman with a child would not want to travel.”

“Tug of War”

Sometimes gender bias against women can spark conflict among women. Often this is due to a pass-through of the other bias patterns. For example,

“Examples include scheduling meetings, taking meeting notes, planning office parties, etc.”

“My colleagues assume I am a slacker because I have children, even when I come in evenings or weekends to make up time that I have to miss due to my children.” – African-American female aerospace engineer

“I spent 15+ years putting in unbelievable hours, pushing myself to near burn-out for this company prior to having a baby. And now it’s disappointing (the reaction to my reduced schedule). … They don’t come right out and say there’s a problem, but the ‘vibe’ is there and lately I’ve been worried about how secure my position is.” – White female civil engineer

Though one-third of white male engineers disagreed that the flexibility stigma exists at all, some male respondents expressed personal experience with it in this area. This supports research that has found that the flexibility stigma is not experienced solely by mothers. Fathers can also be disadvantaged when taking parental leave.

“My husband (also an engineer in a similar field) is getting to the point that he has significantly more leave accrued than I do, but he’s under more pressure to perform and continue moving up whereas I am not.” – White female mechanical engineer

“More male respondents than female reported that having children did not change their colleagues’ perceptions of their work commitment or competence, which is in line with prior research (Figure 6). When asked about flexible work arrangements, more female engineers than male engineers disagreed that requesting such leave would not hurt their careers. Researchers have identified this as the “flexibility stigma,” driven by the belief that an employee’s reputation, salary, and access to promotions is negatively impacted when they take advantage of flexibility options.”

“Tug of War”

Sometimes gender bias against women can spark conflict among women. Often this is due to a pass-through of the other bias patterns. For example,
"I also feel like I will never be promoted because then they will lose their ‘minority hire’ and have to go find another girl." – White female industrial engineer

The Tug of War bias pattern was also seen between female professionals and administrative staff, with almost 20 percent of women respondents indicating that they found it “difficult to get administrative personnel to do the kinds of support work for me that they do for other engineers.” Almost 25 percent of engineers of color reported this as an issue as well.

**WORKPLACE PROCESSES**

"I didn’t realize until I moved up to [management] how much I was underpaid until I was able to see the entire team’s pay. I also realized the trend was not just with me but the other females on the team." – White female engineer

SWE wanted to determine whether engineers felt disadvantaged in the areas of hiring, promotions, performance evaluations, access to networking and mentoring, and compensation. Though the relationship between unconscious bias and workplace processes is not necessarily cause-and-effect, research has shown that bias can impact the impartiality of workplace decisions. Survey responses to questions on workplace processes indicated that female engineers and engineers of color were more likely than white male engineers to report feeling that they were not fairly treated (Figure 7).

Comments on the issue of equal pay for equal work were expressed by many female engineers, who believed they were underpaid compared with their white male colleagues. Many also expressed annoyance with the challenges they faced with regard to promotions.

"My husband works for the same company in a different engineering group but has already received a promotion and our salary adjustments this year show he is making $5K more than me (although I started to work in engineering months before him). I’m proud of him and believe he deserves his ranking and salary but it’s hard to not wonder if part of my experience is due to discrimination.” – White female aerospace engineer

As mentioned earlier, the existence of the “boys’ club” can have a great impact on access to networking and mentoring opportunities, whether formal or informal. This was expressed by female engineers and engineers of color, particularly around social bonding.

"I miss out on informal social networking opportunities when my colleagues go hunting/fishing/to lunch or happy hour and don’t invite me. I see how critical that interaction is to promotion within the company, I am considering leaving the field altogether after 13 years as I don’t see a way for me to advance my career and am frequently lonely at work." – White female mechanical engineer

"Often times I have felt isolated, misunderstood, and like an outsider … It has been a struggle to find supportive mentors and sponsor[s], people willing to help you because they care about you as a person not because they are checking a box or were forced to by their managers." – Hispanic female aerospace engineer

**DISCUSSION**

Unconscious bias can have a decidedly negative impact on workplace climate and individual career trajectories. To date, research on unconscious bias has relied primarily on social psychology lab experiments. This study is unique in its focus on the actual workplace, offering self-reported data that confirms what the lab studies have found: That

the beliefs of acceptable masculine and feminine behaviors (the ‘Tightrope bias') can fuel struggles when some women act as traditionally expected and others do not. Sometimes women hold other women to higher standards (the Prove-It-Again bias), expecting female colleagues to prove that they can handle what it takes to succeed. Conflicts can occur when work schedule issues arise (the Maternal Wall bias). Research has found that competition can also fuel conflict, particularly when women feel that they must fight for the “woman's slot” because I don’t have any women colleagues.” – White female chemical engineer

One out of five female respondents indicated the belief that a woman's slot exists in their engineering workplace.

"I work at a company that is spread out over a large number of small offices. As a result, I am the only female engineer in my office, and I barely know the other female engineers in the company.” – Female mechanical engineer

"I don’t compete with my female colleagues for the ‘woman’s slot’ because I don’t have any women colleagues.” – White female chemical engineer

"I 100% believe there is a ‘woman’s [slot]’ and have had very senior people in my organization confirm that they also believe that exists.” – White female computer scientist

As mentioned earlier, the existence of the “boys’ club” can have a great impact on access to networking and mentoring opportunities, whether formal or informal. This was expressed by female engineers and engineers of color, particularly around social bonding.
the climate in engineering is tougher for female engineers and engineers of color than it is for white male engineers.

The female engineers surveyed reported statistically significant differences from white men for many of the questions asked within three of the four bias patterns. Only Tug of War was found to be weak, primarily because most women surveyed were the only female engineer or one of very few in their workplaces. Engineers of color reported more Pre-It-Again and Tightrope biases than their white counterparts, experiencing challenges in combating the stereotype of what people expect an engineer to look like or how they are expected to behave.

The impact on workplace processes is what is most concerning. As we continue to question why more women and people of color choose not to pursue an engineering career or choose to leave, we must acknowledge the obstacles that they encounter in common workplace practices. Being asked to do administrative or housework tasks while being denied opportunities to high-profile projects will have an impact on an engineer’s career progression.

The “boys’ club” that still appears to exist in many workplaces leaves out those who do not fit in the club, resulting in less access to networking and mentoring opportunities. Even coming straight out of college and offered a lower starting salary than another for the same level of position places an engineer at a disadvantage from the beginning of their career. Starting from behind coupled with less access to career advancement opportunities makes it that much harder to move up.

Interestingly, the hesitancy to take advantage of those options, however, must be addressed. Only Tug of War was found to be weak, primarily because most women surveyed were the only female engineer or one of very few in their workplaces. Engineers of color reported more Pre-It-Again and Tightrope biases than their white counterparts, experiencing challenges in combating the stereotype of what people expect an engineer to look like or how they are expected to behave.

The impact on workplace processes is what is most concerning. As we continue to question why more women and people of color choose not to pursue an engineering career or choose to leave, we must acknowledge the obstacles that they encounter in common workplace practices. Being asked to do administrative or housework tasks while being denied opportunities to high-profile projects will have an impact on an engineer’s career progression.

The “boys’ club” that still appears to exist in many workplaces leaves out those who do not fit in the club, resulting in less access to networking and mentoring opportunities. Even coming straight out of college and offered a lower starting salary than another for the same level of position places an engineer at a disadvantage from the beginning of their career. Starting from behind coupled with less access to career advancement opportunities makes it that much harder to move up.

Interestingly, the hesitancy to take advantage of those options, however, must be addressed. Only Tug of War was found to be weak, primarily because most women surveyed were the only female engineer or one of very few in their workplaces. Engineers of color reported more Pre-It-Again and Tightrope biases than their white counterparts, experiencing challenges in combating the stereotype of what people expect an engineer to look like or how they are expected to behave.

The impact on workplace processes is what is most concerning. As we continue to question why more women and people of color choose not to pursue an engineering career or choose to leave, we must acknowledge the obstacles that they encounter in common workplace practices. Being asked to do administrative or housework tasks while being denied opportunities to high-profile projects will have an impact on an engineer’s career progression.

The “boys’ club” that still appears to exist in many workplaces leaves out those who do not fit in the club, resulting in less access to networking and mentoring opportunities. Even coming straight out of college and offered a lower starting salary than another for the same level of position places an engineer at a disadvantage from the beginning of their career. Starting from behind coupled with less access to career advancement opportunities makes it that much harder to move up.

Interestingly, the hesitancy to take advantage of those options, however, must be addressed. Only Tug of War was found to be weak, primarily because most women surveyed were the only female engineer or one of very few in their workplaces. Engineers of color reported more Pre-It-Again and Tightrope biases than their white counterparts, experiencing challenges in combating the stereotype of what people expect an engineer to look like or how they are expected to behave.
Title IX at 45

The 45th anniversary of Title IX, the groundbreaking antidiscrimination law ensuring protection against sex discrimination in education, is this June. Experts weigh in on progress made in recent years, and what is needed to ensure it continues.

By Sandra Guy, SWE Contributor

Rising above partisanship and gender politics, Title IX has historically garnered support from both Democrats and Republicans. This, according to Lisa Maatz, vice president of government relations and advocacy for the American Association of University Women (AAUW), is because the law guarantees equal rights to an education for girls and boys, and women and men. Title IX’s mandate extends far beyond its widely known role in expanding women’s access to athletics programs.

“Title IX is hugely popular, and it’s a bipartisan issue. We don’t expect that to change,” Maatz said.

Echoing this sentiment, Sue Klein, Ed.D., education equity director for the Feminist Majority Foundation and a 34-year veteran of gender-equity research at the U.S. Department of Education, notes that many state and local laws also guarantee equal education rights to girls and boys and to women and men, and that federal agencies such as NASA, the National Science Foundation, and the Department of Justice support gender-equity education programs and activities along with the Education Department.

Dr. Klein and the Feminist Majority Foundation urge Title IX supporters to show their commitment to ending sex discrimination in their own communities by building on the Obama administration’s good work, including providing guidance, tools, and public enforcement decisions that have fortified Title IX. In view of all the unknowns posed by a new administration in Washington, advocates are also preparing to celebrate the groundbreaking antidiscrimination law’s 45th anniversary in June, making Dr. Klein’s recommendation all the more timely.

AT THE CORE OF COMPLIANCE: TITLE IX COORDINATORS

The people responsible for making sure Title IX works in schools, colleges, and universities across the country are called coordinators. At least one Title IX coordinator is required to work in every institution nationwide that receives federal funds for education programs or activities, and information about how to contact them should be posted on each school’s website.

Indeed, the Obama administration’s Department of Education encouraged greater attention to the important roles of required Title IX coordinators by providing the Title IX Resource Guide (http://www2.ed.gov/about/offices/list/ocr/docs/dcl-title-ix-coordinators-guide-201504.pdf) and the names, emails, and other ways to contact Title IX coordinators in 16,000 school districts and 7,000 colleges and universities, Dr. Klein said.

These school district Title IX coordinators are also encouraged to train and work with counterparts in all their public schools, to establish teams of coordinators with expertise in many areas of Title IX responsibility, such as ending sex discrimination and gender stereotyping in academics, athletics, employment, disciplinary practices, and sexual harassment and assault.

For example, Stop Sexual Assault in Schools (http://stopsexualassaultinschools.org/) has released its action plan on video, “Sexual Harassment: Not in Our School,” which showcases a student gender equity group learning from legal and education experts, student survivors, Title IX coordinators, and victim assistance providers about practical ways to ensure that their schools provide safe and equal learning opportunities.

That’s important because of intensified efforts by students, elected officials, and the Obama administration to deal with issues such as sexual violence, sexual harassment, LGBTQ discrimination, and equal access for women and girls to science, technology, engineering, and mathematics (STEM) programs, and to college lab space, research assistants, and other support proportionate to their male colleagues.

The result? The workload at the Title IX enforcement office exploded. Yet, at the same time, a Republican-led Congress constrained the budget of the Office for Civil Rights at the U.S. Department of Education, which enforces the Title IX law that prohibits discrimination on the basis of sex.

The Office for Civil Rights was inundated with more than 16,000 civil rights complaints in 2016, more than twice the 6,854 filed in fiscal year 2009 — yet the staff is at 1980s levels, according to the latest Office for Civil Rights’ yearly report.

Of those cases, the Office resolved 1,346 Title IX complaints that ranged from schools’ handling of athletics to sexual harassment and more. That’s almost two cases every hour for the entire year.

The increase in Title IX complaints at the Office for Civil Rights is a strong indication that Title IX coordinators at schools, colleges, and universities across the country are dealing with additional cases as well.

Yet there’s a rub. No requirement exists that the federal government pay for Title IX coordinators. So even when the coordinators are doing the work and states are complying with the law, no specific federal funding is set aside for it.

That’s in spite of Title IX coordinators’ mandate to perform various levels of complex tasks:

• Monitoring the gender ratio in STEM courses
• Working to monitor and end sexual harassment and violence
• Supporting pregnant and parenting students
• Overseeing the prompt investigation of complaints alleging sexual harassment
• Reviewing findings as to whether sexual harassment occurred
• Keeping apprised of proposed remedies to address sexual harassment, eliminate any hostile environment, and prevent its recurrence; and
• Serving as a consultant to any disciplinary hearing panel where sexual harassment has been determined to have occurred to ensure compliance with Title IX

Reviewing 13 areas of an athletics program when assessing Title IX compliance
• Investigating sex discrimination complaints that fall outside of sexual harassment and sexual assault, such as employment and sex segregation
• Training others, such as teachers, parents, and campus law enforcement officers, on the many aspects of Title IX

TRAINING IS ESSENTIAL

Besides fully staffing the Title IX coordinators’ posts, the coordinators themselves need to be properly trained and valued as gender equity leaders to fully realize the law’s intent, Title IX advocates say.

To that end, the AAUW has launched a campaign to recruit volunteers to distribute the Education Department’s Title IX Resource Guide and other materials to Title IX coordinators so they can better understand and perform their
Dr. Klein said though public and private institutions that receive federal funds for education are covered by Title IX, like most other federal civil rights laws, Title IX itself has no “designated pot of money” for Title IX compliance.

Ideally, federal and state funding to help implement Title IX could be had by enacting a next-generation version of the 1974 Women’s Educational Equity Act, as well as providing additional funding for gender equity in STEM, in career and technical education, and to prevent sex discrimination in many other areas such as sexual harassment and assault, Dr. Klein said.

U.S. Sen. Mazie Hirono, J.D., D-Hawaii, and U.S. Rep. Louise Slaughter, D-New York, proposed the Patsy Mink Gender Equity in Education Act, which would provide resource centers, training for Title IX coordinators, and coordination of gender equity work.

Dr. Klein said Title IX coordinators and everyone else concerned with educational equity also need to be concerned that charter schools and even some public schools pay special attention to integration and diversity rather than sex, race, and other types of segregation.

In December 2014, the Office for Civil Rights issued guidance about the need for evidence-based justifications for sex-segregated classes or schools since separate is not equal, and research is showing that it generally increases sex stereotyping and sex discrimination (See www.feminist.org/education/sexsegregation.asp for links).

Four Decades of Title IX

Though Title IX is associated most closely with boosting girls’ athletics, the law also is intended to protect girls and women from bullying, support their STEM career aims, and ensure they are not separated in same-sex classrooms that pander to learning stereotypes.

Details of Title IX’s expansive reach, including ensuring pregnant and parenting teens succeed in high school, are described in the publication “Title IX: Working to Ensure Gender Equity in Education.”

Updates to the original report, released in 2012 to celebrate the 40th anniversary of the legislation, based on a chapter-by-chapter basis February 2017. The report assesses where progress had been made as well as areas in which it lagged. As noted in the introduction to the executive summary:

“Despite tremendous progress, however, challenges to equality in education still exist. Women’s advancement in some areas, including computer science and engineering, has stagnated or even declined in recent years. Pregnant and parenting students are frequently subjected to unlawful policies and practices that deter them from completing their education. Nearly half of all middle and high school students report being sexually harassed in school. And single-sex classrooms often cater to stereotypes about how boys and girls learn, to the detriment of both sexes.”

These and other challenges affect the ability of all students — male and female — to get the most out of their education. This in turn endangers the ability of U.S. schools and universities to produce skilled workers who can succeed in an increasingly competitive global marketplace.

The publication, whose STEM section relied upon SWE’s input, was published by the National Coalition for Women and Girls in Education, a Washington, D.C. – based nonprofit, with whom SWE is affiliated.

The report explains issues and recommended solutions in six areas covered by Title IX: athletics; science, technology, engineering, and mathematics (STEM); career and technical education; sexual harassment; single-sex education; and the rights of pregnant and parenting students.

Each chapter update is taking place on an ongoing basis, offering recommendations to fulfill Title IX’s goals, and the report urges increased awareness, enforcement, transparency, coordination, and funding to make Title IX’s promises a reality. Please visit www.ncwge.org
Dr. Klein pointed to comments by Feminist Majority Foundation Policy Director Gaylynn Burroughs, J.D., in the Winter 2016 edition of Ms. magazine, titled “Not Going Back: Here’s Where We’re Drawing a Line in the Sand to Defend Our Rights.” (page 24): “Our public schools should not promote such blatant sex stereotypes, which have a particularly harmful impact on girls and on trans and gender-nonconforming students.”

Dr. Klein said when schools segregate girls and boys, boys often receive more and superior resources.

Gender equity advocates are opposed to voucher programs — which allow children to attend private schools — for many reasons, but especially because it has not been established that schools that accept students using public funding for vouchers are required to comply with Title IX and other federal civil rights laws.

None of these issues can be resolved until Title IX coordinators are part of a solid network that ensures comprehensive training and enforcement, according to the Feminist Majority Foundation report.

“Only a few states, such as Connecticut and Oregon, have vertical Title IX Coordinator networks to connect the State Education Agency (SEA) with their district or postsecondary Title IX Coordinators at the school level,” the report states. “There is also no national guidance and little state guidance on how district level Title IX Coordinators could ensure that there are effective Title IX Coordinators at the school level.”

The report continues, “Peer Title IX Coordinators across states, school districts, and schools rarely meet even for training or sharing best practices; and experts from gender equity organizations have not been encouraged to serve as advisors or partners to Title IX Coordinators. Similarly, topic-focused horizontal networking is especially important as Title IX Coordinators address increasingly complicated types of discrimination such as sexual harassment and assault, disparities in academic areas (such as STEM and Career Technical Education) and inequities in educator employment, sex segregated classes and schools, and in athletics.”

Despite the obstacles, Maatz and Dr. Klein, in separate interviews, say they are hopeful that Title IX’s success will continue.

At the beginning of this new administration, “people need to keep in mind what Trump does with his Cabinet,” Maatz said. “We believe personnel is policy. We expect Commerce Secretary nominee Wilbur Ross, Attorney General nominee Jeff Sessions, Education Secretary nominee Betsy DeVos, and other folks to get questions about Title IX and gender equity. DeVos didn’t send her children to public school and didn’t go to public school herself.

“Might a Trump administration try to tweak around the edges or de-emphasize enforcement and technological assistance? That remains to be seen. That’s what groups like AAUW are for — to keep watch on where they’re on track and where they’ve gone off the rails.”

As of this writing, the Associated Press reported on Feb. 28 that lesbian, gay, bisexual, and transgender employees at the Department of Education sent an email to Education Secretary De Vos, seeking her commitment to safeguard Title IX anti-discrimination rules amid fears that the Trump administration may weaken the protections. The New York Times reported on Feb. 19 that the Association of Title IX Administrators (ATIXA) will distribute an updated “playbook” of best practices for enforcing Title IX to 35,000 people at schools, colleges, and universities.

The Times story quotes ATIXA Playbook’s introduction as saying while critics argue that colleges have no business policing sexual violence, this is a “politically opportune moment to offer a spirited defense” of why they should do so.
Growing an Ecosystem to Ensure Gender Equality

Policymakers in Europe and Canada are taking direct and uncompromising approaches toward resolving gender-based inequities.

By Sandra Guy, SWE Contributor

Top science and research bodies in Ireland passed a rule on Dec. 10, 2016, that will require the nation’s publicly funded universities to address gender inequality or lose their research funding. The new policies for Irish higher education include mandatory quotas for academic promotion and requiring candidates for university president to demonstrate that they have promoted gender equality.

The policies will be independently verified and certified by Athena SWAN — an international evaluation and accreditation program — or the universities will be ineligible to receive any research funding. (See https://www.insidehighered.com/news/2016/06/30/)

“Unconscious bias is a real phenomenon and cultural and structural — mean that women face a number of barriers to progression, which are not experienced to the same degree by men.”

The systemic barriers in the universities’ cultures and organizations “mean that talent alone is not always enough to guarantee success,” said Geoghegan-Quinn, who was awarded the French government’s highest honor, the Legion d’Honneur, for her leading role in establishing Horizon 2020, the EU’s €80 billion program for science, research, and innovation.

Leading up to the deadline, Science Foundation Ireland is mandating training to recognize unconscious bias for its staff and board members as well as for independent research-grant reviewers it hires from outside of Ireland.

“We realize that no one is setting out to deliberately discriminate or to be negative about women or anything else. Yet studies show when people become aware of this bias, the chances of its happening and influencing them are much less. We’re scientists. We’ve read the literature and decided when people are sensitized to the issue, they are much less likely to do it.” The training started in 2016.

POSITIVE INCENTIVES WORK

Dr. Ferguson said an experiment that Science Foundation Ireland conducted highlighted the problems of systemic and institutional procedures that result in gender inequality.

The foundation let its seven research universities double the number of nominations, from six to 12, for their best young researchers to be considered for highly sought-after grants considered the first step toward becoming an independent researcher. At least six of the nominees from each institution had to apply because she was a very bright person. The university leaders found these excellent women who for years they had told me didn’t exist — they did exist. One of the successful female nominees told Dr. Ferguson that her supervisor suddenly started encouraging her to apply for the grant. Though she questioned whether she should wait another year, since she had just had a baby, she applied and was glad she did. She was thrilled that her supervisor was positive and encouraging, telling her that she had to apply because she was a very bright person. Why do I think that was a nice story? Dr. Ferguson said. “It speaks to what we were trying to do it.” The training started in 2016.

“WE REALIZE THAT NO ONE IS SETTING OUT TO DELIBERATELY DISCRIMINATE OR TO BE NEGATIVE ABOUT WOMEN OR ANYTHING ELSE. YET STUDIES SHOW WHEN PEOPLE BECOME AWARE OF THIS BIAS, THE CHANCES OF ITS HAPPENING AND INFLUENCING THEM ARE MUCH LESS. WE’RE SCIENTISTS. WE’VE READ THE LITERATURE AND DECIDED WHEN PEOPLE ARE SENSITIZED TO THE ISSUE, THEY ARE MUCH LESS LIKELY TO DO IT.”

— Mark Ferguson, Ph.D., director general, Science Foundation Ireland and chief scientific advisor to the government
WHERE GENDER EQUALITY IS A PRIORITY
Among the historically progressive Nordic countries of Norway, Sweden, Denmark, Iceland, and Finland, gender equality has been a priority for decades, yet their higher-education institutions lag in addressing the issue, said Marja Makarow, Ph.D., director of Biocenter Finland, former vice president of the Finnish Research Councils (Academy of Finland), and chair of the NordForsk Board, whose members represent the Nordic countries’ largest national research funding agencies.

Though Finland’s research councils that make decisions on research funding must be at least 40 percent female, women represent only 25 percent of professors at top universities, according to the 2015 European Gender Equality Index, the latest annual data on such higher-education statistics. The index revealed that the other Nordic countries had similar standings, with Iceland at 24 percent; Norway, 21 percent; Sweden at the EU average of 10 percent; and Denmark at 15 percent.

Yet the 40 percent quota has helped women boost their inclusion as research-funding applicants and awardees for most of the programs to 50 percent. Nevertheless, women in STEM fields represent only 24 percent of total STEM applicants. In Finland, quotas have become a way of life, though not without dissent and years of gradual acceptance, Dr. Makarow said. “No one remembers discussion 25 years ago of whether quotas were good or bad,” she said. “I still can find myself in Europe at similar meetings in which a group is making important decisions involving public funds as the single woman amongst male colleagues. I find it very disturbing and odd because diversity increases collective intelligence.”

Indeed, Norway has gone so far as to impose a quota. Forty percent of the board membership must be female for all public limited companies. If a company fails to do so, it gets delisted (http://kjonnforskning.no/en/2016/10/secret-behind-norways-gender-quotas-success).

In Canada, gender equality has its foundation in the country’s Charter of Rights and Freedoms — the first part of the Constitution Act; the Canadian Human Rights Act; and its employment equity acts. The codification bans discrimination based on sex or gender, among other things. Each province and territory also has specific legislation in place to ensure human rights and employment equity.

With Prime Minister Justin Trudeau proclaiming himself a feminist, the government is strengthening its gender-based analysis of all proposals that go to the Cabinet for a decision, said Suzanne Cooper, senior advisor, external relations at Status of Women Canada.

Minister of Finance Bill Morneau released the Fall Economic Statement that promised the 2017 budget and all future budgets would undergo a gender-based analysis. Such an analysis looks at diversity issues such as gender, age, education, language, culture, ethnicity, geography, income, sexual orientation, ability, and Aboriginal identity, to name a few.

Considering gender in budgeting asks questions such as:
• Does an issue affect diverse women and men in different ways? If so, how?
• Are specific groups more adversely affected by the issue?
• Does the initiative or proposed solution improve the situation for all? Or does it have an uneven effect or create barriers for some?

“In Canada, gender equality has become a much more acceptable concept,” Cooper said. “We have a very strong grasp that it’s something we need to achieve. Now we need to expand the concept to ensure we include all levels of diversity, and acknowledge that there is still work to be done.”

“I STILL CAN FIND MYSELF IN EUROPE AT ... MEETINGS IN WHICH A GROUP IS MAKING important decisions involving public funds as the single woman amongst male colleagues. I find it very disturbing and odd because diversity increases collective intelligence.”

~ Marja Makarow, Ph.D., director, Biocenter Finland

“THE FACT THAT WOMEN ARE NOT FOUND IN THE SAME PROPORTION AS MEN IN THE MOST SENIOR POSITIONS IN HIGHER EDUCATION INSTITUTIONS IS NOT BECAUSE WOMEN ARE NOT TALENTED OR DRIVEN ENOUGH TO FILL THESE ROLES; IT IS BECAUSE NUMEROUS FACTORS WITHIN THE INSTITUTIONS — CONSCIOUS AND UNCONSCIOUS, CULTURAL AND STRUCTURAL — MEAN THAT WOMEN FACE A NUMBER OF BARRIERS TO PROGRESSION, WHICH ARE NOT EXPERIENCED TO THE SAME DEGREE BY MEN.”

~ Máire Geoghegan-Quinn, Ireland’s former European Commissioner

Máire Geoghegan-Quinn, Ireland’s former European Commissioner, on the occasion of being awarded an Honorary Fellowship of the Royal College of Physicians of Ireland
Since our founding in 1950, SWE has been seen as the authority on women in engineering. Throughout the years, we have grown our knowledge bank and recently have reinvigorated our research efforts. This research will expand our value to the community along with contributing to our mission of demonstrating the importance of diversity.

In this publication, we hope to give you a better understanding of what research tells us about the state of women in engineering. The content comes from SWE’s own research as well as important data and information collected from partners in our community. We hope to convey what’s driving the gender gap in STEM and inspire you to help us achieve gender parity.

SWE professional and collegiate members are working to succeed in a discipline that has traditionally been male-dominated. Many of our members can relate to one another as the only female student sitting in engineering class, or the only woman on a job site. SWE has been a source for mentorship, professional development, and networking.

Women have increased their numbers in many professions previously dominated by men, including law, business, medicine, and other STEM fields. For professional engineers, currently less than 15 percent of engineers in the U.S. are women. This number has also been stagnant since the early 2000s. SWE has been working on initiatives for retention by increasing work/life integration and providing professional development opportunities. The results seen in our climate control study are very telling of the current workplace environment.

The climate control study was conducted last year and released in the fall. More than 3,000 professionals with at least two years’ experience as engineers or engineering technicians completed a survey. Respondents were asked questions relating to four basic patterns of implicit bias: Prove-It-Again, Tightrope, Maternal Wall, and Tug of War. Interestingly, the study found not just gender bias, but racial bias as well. And the participants in the survey were passionate about their experiences, with most leaving comments at the end of the survey. A full discussion of the study is found in this issue.

As an excellent accompaniment to this magazine, please see our continuously updated research.swe.org website. It has the full version of our climate control study, including a podcast with the lead researcher. A podcast with two of the SWE literature review authors is also available, highlighting key insights from this year’s review. Also, please check out our YouTube video of the State of Women in Engineering panel discussion, recorded at the WE16 annual conference in Philadelphia, this past October (https://www.youtube.com/watch?v=o_nj7PZPxAE).

In the spirit of our mission, we are pleased to provide this special issue of SWE Magazine, and look forward to working together to achieve a diverse engineering workforce.

Jessica Rannow
SWE FY17 President
@SWE_President

Karen Horting, CAE
Executive Director & CEO
We wish to thank SWE’s Corporate Partnership Council for supporting this project.