STEM EQUITY

MORE THAN JUST NUMBERS
STEM EQUITY: MORE THAN JUST NUMBERS

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More Than Just Numbers

Thanks to research, we recognize and appreciate that a diverse STEM workforce is vital to innovation. It is the basis for developing technologies that truly serve all people, reflects the sense of fairness integral to American society, and ensures a strong position in the global economy.

Through research, we also come to a better understanding of the experiences of underrepresented groups, which can guide us to develop constructive policies and solutions to the low numbers of women and people of color in STEM professions. In this spirit, we offer this State of Women in Engineering issue, which includes our annual review of the social science literature regarding women in engineering, now in its 16th year. For a compilation of all our reviews to date, please see: https://research.swe.org/literature-reviews/.

This issue also includes:

• Messaging to Tween Girls: A Review of the Literature. This summarizes a larger review on literature regarding girls ages 8–12.

• STEM Equity: More Than Just Numbers. Our cover story delves into the available details and possibilities presented by a new program coming to colleges and universities in the United States.

• Reinforcing Best Practices Globally. A successful voluntary program in the U.K. rates universities on gender equality, encourages funders to heed the results, and is expanding.

• Title IX Update. Recent guidance from the U.S. Department of Education has resulted in serious concerns.

• Insights from SWE’s Community College Study. This pathway could be key to diversifying the profession.

• Understanding the Early Career Experiences of Women of Color. A joint study by SWE and the National Society of Black Engineers sheds light on the challenges, strategies, and support for women of color.

• Then and Now: Women Engineers’ Perspectives on Changes and Challenges in the Field Since the 1970s. Insights from this cohort, who came of age at a time when female engineering enrollment had increased rapidly, may help guide current and future policies.

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Our Cover and Illustrations

Our cover graphic and several images throughout this issue are hand-rendered Spirograph® illustrations. The Spirograph became a popular children’s toy in the 1960s, but its roots are in engineering and mathematics. Invented by British engineer Denys Fisher in 1962, the Spirograph joined the ranks of other mechanical devices designed over the years to function as mathematical kinematic models. That’s because long before computer-aided design (CAD) and three-dimensional graphics were available, mathematical kinematic models were useful in drawing the properties of curves.

For a time, the Spirograph was billed as the number one educational toy in the United States. It even inspired an article, “Mathematics of the Spirograph,” by Robert J. Whitaker, Ph.D., faculty member of the department of physics and astronomy at Southwest Missouri State University, where he explored how cycloidal curves in mathematics could be produced using the Spirograph. Our use of the images here is a bit of mathematical and artistic whimsy, inspired by our cover story, STEM Equity: More than Just Numbers.

Sources:

http://americanhistory.si.edu/blog/2014/03/the-spirograph-and-kinematic-models-making-math-touchable-and-pretty.html

Sources:
Women in Engineering: A Review of the 2017 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.

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The fact that there are relatively small numbers of women in engineering and other math-intensive, technical fields is rapidly becoming a topic of interest to more than the readers of SWE Magazine, academics, and experts on gender inequality. Several years of headlines describing sexual misconduct and the mistreatment of female employees in the tech sector has made Americans in general aware of the fact that not only are there very few women in those industries, but the ones who are there frequently face unequal, discriminatory, and often hostile treatment by their male superiors and colleagues. It is hard to escape the conclusion that these two facts are related — the low numbers of women in engineering and tech expose them to a hostile culture, while increasing the numbers of women in those fields is simultaneously made difficult by the existence of that culture.

This year’s review of the literature on women in engineering, thus, has added currency. What can we learn from academic research about the reasons for the persistent underrepresentation of women in engineering and other technical fields? Is there any reason to hope that the historical pattern will change in the foreseeable future? And, can academic research provide us with a better understanding of how pervasive the experience of a hostile culture in tech actually is, what its roots are, and how much effect it has on keeping the numbers hostile culture in tech actually is, what its roots are, and how much effect it has on keeping the numbers low?

As in previous years, the review team surveyed academic publications and conference proceedings for the latest research on women in engineering and related fields. We identified more than 160 articles, books, and papers in a variety of disciplines for review. From these, we selected those based on extensive research and the best scientific methods as well as those that offered new insights into established research questions or that posed new questions worthy of further investigation. Because one goal of SWE’s literature review is to disseminate information about exemplary research, and to encourage more researchers to conduct careful, academically sound studies, we say less here about studies based on one or two examples or that report on opinion rather than research findings.

This year’s review did not reveal any radically new research directions in the literature on women in engineering. Although we read a number of very strong articles that reported on well-conducted research, they generally focused on familiar questions such as why there are so few women in engineering as central to understanding the low numbers of women in engineering. Although we read a number of very strong articles that reported on well-conducted research, they generally focused on familiar questions such as why there are so few women in engineering as central to understanding the low numbers of women in engineering, and, to a lesser extent, the challenges facing by female engineers employed outside the academy. Last year, we noted that explanations for the low numbers of women in engineering tended to focus either on the reasons why there are so few female engineers.

We were struck, this year, by the increased number of well-conducted studies of women in engineering outside the U.S., particularly in Europe. The review has always included international studies, but the quality of those studies seemed considerably higher, on average, than in the past. For that reason, we have included detailed discussion of a number of international studies in the review. Adding a comparative dimension to the study of women in engineering is a welcome development, as one cannot help but assume that conditions in the U.S. pertain elsewhere (as several of the studies we reviewed this year make clear).

It was also notable, given the high volume of journalistic reports of a hostile climate in technical workplaces, that very few studies were published this year that attempted to shed light on the nature of that climate and how it affects women engineers. Perhaps this is simply a matter of timing — conducting careful academic studies can take years, so it may take time for academic researchers to “catch up” to the issues raised by news events. Still, this is an obvious direction for future research; as studies we have reported on in previous years make clear, achieving gender integration in engineering involves not simply changing women’s interests and preferences but also making engineering a less-gendered place in which women can feel they belong. For that to happen, a better understanding of the gendered culture of contemporary engineering is an obvious need.

WHERE DOES IT BEGIN?

One enduring theme in the literature on the underrepresentation of women in engineering and related STEM fields focuses on childhood experiences. As in past years, we reviewed several articles this year that documented the early development of gendered differences in interests among children; the early emergence of stereotypical beliefs about math, science, and engineering among children; and the ways in which adults, whether consciously or unconsciously, contribute to the development of these differences.

Bian, Leslie, and Cimpian (2017) report on an experimental study of 400 children conducted in 2017 at the University of Illinois. The experiments were designed to examine at what age children begin to develop stereotypical views about intellectual abilities and how this affects their interests. The researchers found that stereotypes developed quite early, as early as age 6, and that there were differences between boys and girls in their study. One experiment showed that by age 6, girls were much less likely than boys to associate “brilliance” with their own gender. Other experiments found that girls were less interested than boys in games labeled as being for “smart” children and that, by age 6, girls (but not boys) had begun to show reduced interest in games for “really, really smart children.” Since other research has shown that there is a belief being good at math and science is related to “brilliance,” these findings suggest a possible reason for girls’ reduced interest in entering STEM fields.
Speer (2017) analyzed data from the National Longitudinal Study of Youth, finding that, by the time teenagers apply to college, measurable differences in preparation, as measured by test scores, have developed and that these are significant predictors of choice of college major. Speer argues that these differences are more significant than has been shown by previous studies. Typically, researchers focus on SAT scores, which account for only a small portion of the differences between males and females in major choices. Speer focuses, instead, on the Armed Services Vocational Aptitude Battery (ASVAB), which respondents to the National Longitudinal Study of Youth in 1980 and 1999 completed. The differences between boys’ and girls’ scores on this test accounted for a much more significant portion of the gendered differences in major choice, which led Speer to conclude that researchers may have underestimated the size of the aptitude differences that have developed by the time children enter university. Speer is not able to say what causes these differences to develop. One can also ask how important different outcomes on the ASVAB actually are, since few universities use this test to evaluate applicants. The test scores he examines are also over a decade old, and he acknowledges that girls’ scores in science and math have improved over time. Nevertheless, Speer’s study demonstrates the early development of differences between boys and girls on tests of ability and knowledge in various subject areas; it is reasonable to assume that such differences are likely to influence students’ eventual choice of major in college (and career).

Francis et al. (2017) describe the development of gender stereotypes about physics among older children. Using interview data from 70 respondents drawn from the British Economic and Social Research Council’s study of “young people’s science and career aspirations,” they describe a variety of “discourses” teenagers (and their parents) employ in talking about physics. Most women do not use the “discourse of equality of opportunity,” which sees physics as meritocratic. Instead, more women apply a discourse that perceives gender discrimination and obstacles to women’s entry. Both men and women, however, often resorted to a discourse that defined physics as masculine; this included a variety of elements, including the view that certain subjects are masculine or feminine, that men and women are naturally drawn to different subjects, and that physics requires cleverness, which was defined as a masculine trait.

Finally, Ball et al. (2017) conducted an analysis of a sample of more than 1,000 students in an urban, predominantly minority school district in the southeastern United States. They used expectancy-value theory (EVT) to examine the students’ attitudes with regard to STEM. This theory — EVT — holds that attitudes are shaped both by expectancies for success and by “subjective task value,” which comprises several elements, including utility value (how useful does one see something in helping to achieve a desired end) and intrinsic value (how much interest and enjoyment does one derive from the activity). Ball et al. found that intrinsic value was the strongest predictor of high scores on math and science affinity, which they believe.

It Could Have and Should Have Been Different

Contemporary Americans know that technical work, especially work that demands mathematical skills and involves programming computers, is one of the most routinely masculine segments of the labor market. But, as Jennifer Light wrote a number of years ago in an article in the historical journal Technology and Culture, there was a time, not so very long ago, when “computers were women.” The publication last year of Hidden Figures, and the subsequent popular film based on the book, hinted that this was the case (although the focus, there, was on race more than gender). Two books published this year continue the process of dismantling the notion of a male-only computer field. Both men and women, however, often resorted to a discourse that defined physics as masculine; this included a variety of elements, including the view that certain subjects are masculine or feminine, that men and women are naturally drawn to different subjects, and that physics requires cleverness, which was defined as a masculine trait.

When it was realized that computer programming required higher levels of skill, employers ignored the female labor force and tried to redefine the work as masculine by defining it as management. This led to persistent labor shortages, as women were ignored and men with management ability either lacked technical skills or were lured away into other, nontechnical fields. British computing languished as a result. As these histories clearly demonstrate, women did have and continue to have the ability to enter technical fields, but in the past were let in only because of a wartime emergency or the newness of the field. While defining their work as routine gave women access, it limited their ability to become a truly technical labor force. When technical work was seen as requiring real skill, perhaps even genius, men were sought exclusively. Sadly, both of these books indicate that it could have and should have been different. The early women “computers” were much more than routine workers, and there also were female geniuses in the field. A small number of these women persisted after war, albeit by not marrying or having children.

Liza Mundy’s Code Girls relates the “untold story of the women code breakers of World War II.” Mundy’s book, written for a popular audience, recounts how both the United States Army and Navy, faced with the need to recruit large numbers of code breakers, hired a sizeable number of talented young women who had previously served as teachers and/or were recent graduates of prestigious colleges to do the job. Mundy estimates that, at its peak in 1945, the Army’s code-breaking operation employed 10,500 people, about 70 percent of whom were women. The Navy had 5,000 code breakers in Washington, D.C., 80 percent of whom were women (although the Navy’s overseas code-breaking labor force was largely male). Recruiting women as code breakers was not just a high-tech version of the familiar “Rosie the Riveter” story. As Mundy points out, code breaking barely existed before the war, so there were no barriers to women’s entry into the field and no stereotypes to overcome. In fact, Mundy argues, a group of highly talented women dominated the very small U.S. code-breaking effort prior to World War II, so recruiting more women to the field hardly seemed strange.

Moreover, although accounts of wartime code breaking tend to focus on the genius of individual male heroes such as Alan Turing, Ph.D., the reality is that the work was defined as routine and meticulous, perfectly consistent with prevailing stereotypes about women’s tolerance of and talent for such work. The military also quite consciously decided to adopt an assembly line approach to the work, which raised their comfort level with a largely female labor force. Once the war was over, the women were expected to return home, and most did, although some were quite reluctant. In Programmed Inequality, Marie Hicks, Ph.D., tells the story of women’s role in wartime code breaking and the post-war computer industry in Great Britain. Dr. Hicks describes how the early British computer industry actually had its origins in wartime code breaking, as the work done at the famous Bletchley Park was the result not just of the genius of men such as Dr. Turing, but of early computing machinery and of a largely female labor force. The women who worked at Bletchley Park were more than deskilled functionaries, but, their role was obscured by the general perception that they were working on office machines performing relatively routine tasks.

After the war ended, some of the wartime female code breakers migrated to the government’s emerging computing effort. They were defined as low-level clerical workers and machine operators, however. In fact, Dr. Hicks notes that, fairly soon after the war, they were actually downgraded, so that they were classified as even lower than conventional clerical workers. The result was that computing work in post-war Britain was dominated by a deskilled labor force, and Britain’s computing effort failed to take advantage of the real talents possessed by the women it employed. Dr. Hicks argues that, in the end, this proved to be the undoing of the British computer effort.
is linked to more positive attitudes toward STEM. There were gender differences, however. Utility values and expectancies had a stronger effect on girls’ than on boys’ attitudes toward the importance of math and science. The researchers hypothesize that this may be related to the fact that girls had lower utility values and expectancies than boys. This case study points to another difference between males and females and their attitudes toward STEM that develops during childhood.

Just how such gendered attitudes in young children develop remains a matter of some dispute, a fact reflected in the research we reviewed this year. Some regard the emergence of gender differences as more or less “natural,” not something that is socially conditioned. An example of research that comes close to making this kind of argument is Buser, Peter, and Wolter’s (2017) study of 250 students in Bern, Switzerland. They found that willingness to compete in eighth grade was an important predictor of choosing a math-intensive specialization 1.5 years later in Swiss academic high schools. The gender differences they found in willingness to compete (with boys being more willing) accounted for some of the gender differences in students’ educational choices.

Other studies we read pointed quite explicitly to social influences that encourage boys and girls to develop stereotypical attitudes and to make choices that are influenced by them. Eliasson, Karlsson, and Sorensen (2017) conducted a study of science classrooms in six schools in Sweden. Using videotape of science lessons taught by seven male and seven female teachers, they found that teachers tended to pose largely closed questions and that boys were much more likely to answer those questions. The authors speculate that this may reflect the fact that, unlike open questions, closed questions typically have one answer and that it’s easier to shout out answers to such questions, something boys are more likely to do. In contrast, open questions seemed to invite more participation by girls, although the number of such questions observed was small, so drawing firm conclusions is risky. Interestingly, the authors argue that closed questions are lower-order questions, requiring the lowest level of thinking skills, so their use in classrooms actually impoverishes science teaching. Therefore, it is possible that a different approach, focused more on higher-order thinking, would both enhance the teaching of science and promote gender equality in classrooms.

Colette and Marjolaine (2017) examined the gendered nature of material artifacts in technology textbooks in France. They inventoried the artifacts, then submitted the list to a group of almost 100 girls and boys ages 12–14, asking them whether they felt the objects were masculine or feminine. The children considered most of the objects to be gender neutral, but those that were gendered tended to be perceived as masculine (of interest or concern to boys, rather than girls). The authors add that the number of such objects increased in the textbooks targeting 14-year-olds, so the pattern grows more pronounced as children age. They conclude that this is evidence that technical education is more focused on the interests of boys and imply that this may help to explain why more boys than girls are attracted to technical fields.

Jacobs, Ahmad, and Sax (2017) argue that there is strong evidence that parents’ occupations influence children’s major and career choices and that they do so differently for girls and boys. Using data from a national, longitudinal study of college students in the U.S. between 1976 and 2011 (comprising data on nearly 1 million first-year students), they find that both fathers and mothers affect the choices of both sons and daughters. However, sons are more likely to follow in their fathers’ footsteps than their mothers, although the role of mothers has become somewhat more salient for boys. Girls used to be more likely to follow in their fathers’ footsteps, but, since the 1990s, mothers have been more influential. The daughters of engineers are much less likely than the sons of engineers to follow their parents into engineering (although the daughters of engineers are more likely to choose engineering than those whose parents are NOT engineers). As mothers’ influence has grown, it is likely that daughters of female engineers will grow increasingly likely to choose engineering themselves. The effects of this trend, however, are muted by the fact that there are still very few female engineers (thus few mothers to follow into engineering) and by the fact that girls’ interest in engineering as a profession remains relatively low — maternal influence would have to push against this fact. Jacobs et al. do not describe the mechanisms by which parents influence their children’s choices, but their research points to the important effects of childhood experiences on major and career choices later in life.

In sum, research published this year provides continued evidence that, quite early in life, boys and girls view engineering, math, and science through a gendered lens and develop interests and make choices that are linked to those stereotypes. This points inevitably to the conclusion that efforts to increase the numbers of women in engineering need to begin early and to be sustained throughout the precollege years. As Fouad and Santana (2017) argue in their review of the literature on the role of gender in shaping children’s desire to enter STEM fields, at each age level, girls face challenges that tend to undermine their beliefs that they can be successful in STEM careers; there is a need for effective interventions at each level to help girls overcome these challenges. Early on, effective interventions should target parents, who have significant influence on the attitudes of younger children; for teenagers, summer programs and other school interventions can stimulate girls’ interest in STEM by increasing their exposure to the field and giving them a sense of efficacy; and, all of this needs to be followed up by mentoring of female students once they decide to pursue a STEM pathway.

WHY GIRLS DON’T CHOOSE ENGINEERING IN COLLEGE

The largest group of articles and papers we reviewed this year focused on the college years, examining why few women choose to enter engineering programs, as well as the gendered dynamics of the programs themselves. Much of this research winds up showing that what happens in college is a continuation of processes that began earlier in students’ lives (the kinds of processes described in the previous section of this review). However, there was also an emphasis in this year’s literature on the role played by college faculty in gendering undergraduate education. This is an important direction in research and one that warrants further investigation.

Cheryan et al. (2017) provide a framework for understanding the processes by which women are steered, or self-select, away from engineering and related disciplines in college. Their meta-analysis

### Engineering Bachelor’s Degrees by Gender within Race/Ethnicity, 2016

<table>
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<th>Race/Ethnicity</th>
<th>Male</th>
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Source: Yoder, Engineering by the Numbers, American Society for Engineering Education, 2017
of the literature on this issue emphasizes that some STEM fields are more gender balanced than others and points to three major reasons this may be the case. First, some fields are characterized by a masculine culture that signals a lower sense of belonging for women than for men. A second factor is women’s having insufficient early educational experiences in fields such as engineering, physics, and computer science. Finally, although they find the evidence here to be mixed, they note that some researchers have found large gender gaps in women’s self-efficacy in engineering, computer science, and physics and that this helps to explain why they don’t choose to enter these fields.

Several studies we reviewed this year provided evidence of the continued importance of the first factor identified by Cheryan et al. — the masculine culture of engineering. Many of these examined the question of whether women feel they “belong” in engineering and other math-intensive fields and, if they don’t, how this affects their willingness to enter them. Tellhed, Bäckström, and Björklund’s (2017) study of more than 1,000 Swedish high school students found that gender differences in interest in STEM were related to women’s lower degree of belongingness in STEM, although this was less important than self-efficacy. Schuster and Martiny (2017) found that when stereotypes were activated in experimental settings, e.g., by constructing scenarios in which an oral exam was conducted by a male professor in an obviously predominant context, female German university students anticipated less positive affect, which reduced their interest in entering STEM.

Ehrlinger et al. (2017) also examined the role of stereotypes in shaping interest in engineering and computer science. Although this study is based on a relatively small (fewer than 200 respondents) and unrepresentative sample, it points to the persistence of stereotypical views of engineering and their continued role in steering women away from the profession. The researchers asked under-graduate students in psychology classes to rate the prototypical member of the occupation of engineer and computer scientist on a series of traits (logical, intellectual, social, emotional, etc.) and then to rate themselves on those traits. In each case, women rated themselves as being less similar to the prototypical member of these occupations than men did; women also tended to have more positive views of the intellectual abilities of the members of those occupations, and less positive views of their own intellectual abilities. All of this predicted women’s lower interest in entering these fields. Discouragingly, the study found no relation between exposure to engineering or computer science and women’s stereotypical views of those fields, raising questions about whether interventions designed to increase women’s exposure to engineering will do any good (perhaps exposure to female engineers or computer scientists is what is needed?).

Diekman et al. (2017) review research on a related issue that has been the focus of research reviewed in previous years — do males and females have different beliefs, motives, and goals, and does this affect their interest in engineering and STEM careers? Their review finds that research confirms that women have a stronger communal orientation than men, and that goal congruity, i.e., aligning careers with their orientation, is an important determinant of individuals’ career choices. Engineering and some other STEM fields do not align well with women’s communal social roles, which helps to explain why few women pursue these careers. Diekman et al. emphasize that attracting more women to engineering is not simply a matter of “featuring” its communal aspects (as some earlier research has suggested). Instead, the development of goal congruence is a lengthy process that must be sustained; thus, women must also experience goal congruence upon entering engineering programs and careers if their choice of that direction is to be sustained.

Marrero et al. (2017) describe a program designed to combat the second obstacle Cheryan et al. (2017) identify as an important cause of the underrepresentation of women in engineering and related STEM fields’ limited exposure. The program was an effort to recruit more women and underrepresented minority students to STEM through an undergraduate program at Mercy College in New York in 2014 and 2015. Participants had opportunities to undertake a research experience, including a collaborative field-based research project. Analysis of outcomes showed that participants regarded science as more fun after completing the program and were more likely to see themselves as scientists/researchers. Their perceptions of scientists also became more complex and less stereotypical (fewer images of unkempt scientists in laboratories). Although this is a case study, and not specifically focused on engineering, it suggests that direct experience of engineering work may encourage more women to consider it as a career (although the Ehrlinger et al. research cited above offers a cautionary note).

Finally, several studies we reviewed take up the issue of whether women’s self-efficacy is an important factor shaping their decisions about whether to enter engineering. We have already summarized Tellhed, Bäckström, and Björklund’s (2017) Swedish research showing that lower self-efficacy in women is a powerful factor explaining their lack of interest in STEM. Ehrlinger et al.’s study found that their female respondents tended to have less-positive estimates of their intellectual abilities than their male respondents. Johnson and Muse (2017) analyzed a sample of almost 20,000 first-time, first-year students at a research university in the United States. They found that females were more likely...
than males to self-select into social (education, social sciences, nursing), artistic, or investigative (agriculture, biosystems engineering, science, and math) disciplines. Males were more likely to choose realistic (architecture, engineering, computer science) or enterprising (business, industrial engineering, economics) disciplines. First-generation status increased the likelihood that males would choose realistic majors such as engineering; the same was not true for females. Girls who had completed calculus were more likely to choose both realistic and investigative fields; comparable boys were more likely to choose only realistic fields. From a policy perspective, this implies that efforts to improve girls’ math proficiency alone will not be enough to increase the numbers of girls interested in fields such as engineering. Johnson and Muse’s analysis shows that females reported lower self-efficacy in their ability to analyze math and use computing. This may help to explain why math-proficient girls are not more likely to choose careers in engineering and computer science, where math and computer skills are highly important.

Cadaret et al. (2017) analyzed survey data from a small (211 respondents) sample of undergraduate students majoring in engineering fields. They found that stigma consciousness was a barrier for women attempting to study engineering — women who had greater awareness of the stigma associated with women studying engineering reported more struggles facing with barriers and lower academic self-efficacy. The authors theorize that this can lead to lowered academic performance and, perhaps, to exit from the profession. Although this is a small, exploratory study, it supports the view that lower self-efficacy is one of the obstacles keeping women away from engineering and undermines the importance of systematic efforts to enhance self-efficacy and combat stereotype threat.

It is important to note that not all of the research we reviewed identifies self-efficacy as a highly important predictor of major and career choices, reflecting the ongoing debate described by Cheryan et al. (2017). Thus, Schuster and Martiny (2017) find that women experience lower self-efficacy in STEM, but argue that this alone does not explain their career choices (anticipated positive effect has an independent effect). Still, it seems reasonable to agree with Cheryan et al. that there is a growing body of research indicating that lower self-efficacy in women, particularly with regard to math and computer skills, is one of the factors discouraging them from entering fields such as engineering.

In addition to research examining the characteristics of students that shape major choices, we also read several studies that focused on the role of teachers. This year, we saw articles in the Journal of Engineering Education, the European Journal of Engineering Education, Studies in Higher Education, the International Journal of Learning and Development, and Engineering Studies, as well as ASEE conference papers, that take faculty members, rather than students, as their study population for examining gender in undergraduate engineering education (Beddoes, in press; Beddoes and Panther, 2017; Blair et al., 2017; Blasser, 2017; Cross and Cutler, 2017). This group of studies represents an important development in the research landscape, moving beyond studies that focus only on students.

For example, in an article published in Engineering Studies, Blasser (2017) discusses how in her interviews with 23 engineering professors from different disciplines at one institution, they explain women’s underrepresentation by invoking gendered images to position some engineering disciplines as masculine and others as feminine. Based on her findings, Blasser recommends a change for diversity offices. She suggests that, “To the extent that this is true at other engineering institutions, such offices could focus more on the ways in which popular ideas about the ‘common characteristics’ of women and men often serve to reinforce gender stereotypes in ways that have self-fulfilling effects on the way both faculty and their students think and behave (pp. 40–41).” Additionally, in an article published in the Journal of Engineering Education, Blair, Miller, Ong, and Zastavker (2017) identify three discourses that professors use to construct gender expression and their identities as teachers: 1) gender blindness, 2) gender acknowledgment, and 3) gender intervention. They conclude that professors “most frequently utilized discourses acknowledging gender inequity, which limited their responsibilities to promote equity and highlights the pernicious nature of systemic gender bias” (p. 14). Their interview study was conducted with 16 instructors from three different institutions. Similarly, Beddoes found that the discourses in which professors engaged when discussing the causes of and solutions to women’s underrepresentation in engineering limited the roles that institutional policies could play in addressing underrepresentation. Beddoes’ study was based on interviews with 39 professors at three different institutions from a wide range of engineering disciplines and introduced “studying up” as methodology for grounding research on faculty and policies. Related to those two studies, Cross and Cutler (2017) found that their interviewees drew a distinction between diversity and inclusion. And while they believed that inclusion was within their purview as instructors, diversity lay outside of their control.

Several of these studies about faculty members explicitly identified the need for specific tools to help faculty members enact more inclusive practices (Beddoes and Panther, 2017; Blasser, 2017; Cross and Cutler, 2017). They revealed that while faculty members may be interested in more inclusive practices, they did not have the knowledge or skills necessary to enact those practices. As Cutler and Cross put it, based on their pilot interviews with 10 engineering faculty members: “Many of the participants noted a desire to integrate diversity and inclusion efforts into their classroom, but were not sure of the practical details for implementing such efforts effectively. Multiple participants noted a need and desire for diversity and inclusion training that allowed for authentic dialogue and practical solutions that could be implemented in their classroom” (p. 10). Beddoes and Panther came to a similar conclusion in the context of facilitating teamwork specifically and note that an online training tool (called TARGIT) for inclusive teamwork practices is under development.

In addition to teachers, other adults may play a role in steering college students toward or away from college majors. Simon, Wagner, and Killon continued on page 15
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. Barabino, Ph.D., dean, Grove School of Engineering, City College of the City University of New York
Susamma Barua, Ph.D., interim dean, California State University, Fullerton
Stella N. Batalama, Ph.D., dean, College of Engineering and Computer Science, Florida Atlantic University
Gail Baura, Ph.D., director of engineering science and professor, Loyola University Chicago
Macia C. Belcher, P.E., department chair, engineering and science technology, The University of Akron
Stacy G. Birmingham, Ph.D., professor and dean, science, engineering, and mathematics, Grove City College
Barbara D. Boyan, Ph.D., dean of engineering, Virginia Commonwealth University
Mary C. Boyce, Ph.D., dean, 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, University of Texas at Austin
Emily Carter, Ph.D., dean, School of Engineering and Applied Science, Princeton University
Tina Cho, 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, College of Engineering, University of California, Davis
Teresa A. Dahlberg, Ph.D., dean, College of Engineering and Computer Science, Syracuse University
Marie D. Dahle, Ph.D., chair, engineering, math, and computer science, Aurora University
Natacha DePaola, Ph.D., dean of engineering, Illinois Institute of Technology
Doreen D. Edwards, Ph.D., dean, Kate Gleason College of Engineering, Rochester Institute of Technology
Julie R. Ellis, Ph.D., P.E., professor and department head, Western Kentucky University
Jacqueline A. El-Sayed, Ph.D., vice president for academic affairs, Marygrove College
Elisabeth A. Eschenbach, Ph.D., professor and department chair, Humboldt State University
Liesl Folks, Ph.D., dean of engineering, 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. Hailey, Ph.D., dean of the College of Science and Engineering, Texas State University, San Marcos
Angela Hare, Ph.D., dean, School of Science, Engineering and Health, Messiah College
Wendi Beth Heinzelman, Ph.D., dean of Engineering, University of Rochester
Martha Hogan, Ph.D., dean of Engineering, Richland College
Elke Howe, Ed.D., chair, engineering technology, Missouri Southern State University
Sharon A. Jones, Ph.D., P.E., dean of the Shirley School of Engineering, University of Portland
Maria V. Kalevitch, Ph.D., professor and dean, School of Engineering, Mathematics, and Science, Robert Morris University
Anette M. Karlsson, Ph.D., professor and dean of engineering, Cleveland State University
Laura W. Lackey, Ph.D., P.E., interim dean and professor of environmental engineering, School of Engineering, Mercer University
JoAnn S. Lighty, Ph.D., dean of engineering, Boise State University
Elizabeth Loboa, Ph.D., dean of engineering, University of Missouri
Theresa A. Maldonado, Ph.D., P.E., dean of the College of Engineering and professor of electrical engineering, The University of Texas at El Paso
Charla Miertschin, dean, College of Science and Engineering, Winona State University
Nancy Miller, Ph.D., dean, College of Engineering and Computer Science, Grand Canyon University
Jayathi Y. Murthy, Ph.D., dean of the Henry Samueli School of Engineering and Applied Science, University of California, Los Angeles
Hallie Neupert, dean, College of Engineering, Technology and Management, Oregon Institute of Technology
Elizabeth Jane Orwin, Ph.D., professor and chair, department of engineering, Harvey Mudd College
Sarah A. Rajala, Ph.D., dean of engineering, Iowa State University
Mary Rezac, Ph.D., dean, College of Engineering and Architecture, Washington State University
Kristina M. Rolla, Ph.D., dean of engineering, University of Texas at Austin
Julia M. Ross, Ph.D., dean, College of Engineering, Virginia Tech
Michelle B. Sabick, Ph.D., dean, Parks College of Engineering, Aviation and Technology, Saint Louis University
Anca L. Sala, Ph.D., dean, College of Engineering, Baker College
Elaine P. Scott, Ph.D., dean, School of STEM, University of Washington, Bothell
Joyce T. Shirazi, Ph.D., dean, School of Engineering and Technology, Hampton University
Katherine Snyder, Ph.D., interim dean, College of Engineering and Science, University of Detroit Mercy
T. Kyle Vanderlick, Ph.D., dean and Thomas E. Golden Professor, Yale University
Sharon Walker, Ph.D., interim dean, University of California, Riverside
Jennifer Widom, Ph.D., dean, School of Engineering, and professor, Stanford 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
Jean Zu, Ph.D., P.Eng., dean, Schafer School of Engineering and Science, Stevens Institute of Technology

(2017) conducted a study of 6,767 college students, the majority of whom were STEM majors. The researchers calculated a Bem sex-role inventory (BSRI) score for each respondent, then asked what careers they had been counseled to pursue by school counselors and parents. The results indicated clearly how gender affects what students are encouraged to do, although they also reveal complexity. Males whose BSRI scores indicated high masculinity and low femininity were not more likely to be steered toward STEM; instead, they were encouraged to pursue careers in business, law, politics, or sport. It was males whose BSRI scores reflected low masculinity and high femininity who were most likely to be steered toward STEM. Unsurprisingly, females whose BSRI scores reflected low masculinity and high femininity were unlikely to be steered toward STEM. Only females whose BSRI scores indicated high masculinity and low femininity were encouraged to pursue STEM careers. This research suggests that it is not the sex of the student (are they a man or a woman?) but gender (behavioral manifestations of conventional masculinity or femininity) that affects how adults counsel students about their future directions. This is a case study of one institution, and the sample was not representative of the national student population. Nevertheless, it points to an important issue for future research: How do perceived gender and the presentation of gender affect women’s experiences with engineering and STEM, an issue also addressed in a
different context in the article by Alfrey and Twine (2017), discussed below.

THE WORKPLACE

In past reviews, we have bemoaned the remarkable shortage of significant, well-conducted studies of engineering workplaces, particularly nonacademic workplaces. This year, happily, we reviewed several articles that consider what happens to engineering graduates after they leave school. There remain many gaps in this literature, one of which we emphasize in the conclusion to this review. Nevertheless, it is encouraging to see more researchers examining the dynamics of engineering labor markets and engineers’ workplace experiences.

Previous researchers have devoted attention to the transition from college to engineering employment. The percentage of engineering graduates who are female has typically exceeded the percentages of women in the engineering labor force, so the focus has been on understanding the “leak” in the pipeline from school to work. We did not review any studies of this leaky pipeline issue this year. However, two studies considered whether there are barriers to women’s entry into engineering.

Sassler et al. (2017) analyzed data from the 1979 National Longitudinal Survey of Youth; this represents the first NLSY cohort in which women were more likely than men to complete a university degree. The researchers were interested in particular in determining whether women’s family expectations or career orientation affected the probability of their successfully making the transition to STEM employment. Their results did not show any relationship of this type: Women with stronger family plans were no less likely to enter STEM jobs than those with a stronger career orientation. Career-oriented men, however, were more likely to enter STEM employment. The authors see evidence of employer bias here—men appear to be rewarded for a strong career commitment while women with similar career orientations are not. Despite this, the authors conclude that the most important reason for the underrepresentation of women in STEM employment is the underrepresentation of women in STEM disciplines. Interestingly, among STEM disciplines, female engineering students were more likely to enter a STEM job than majors in the biological and physical sciences.

Cardador (2017) interviewed 61 engineers who were the alumni of an undergraduate engineering program in the U.S. The study found that the movement into management by women was in some ways negative. The women themselves had weaker identifications with technical roles being seen as masculine and, simultaneously, valued more highly. Ironically, then, women’s upward mobility in engineering made engineering seem more male.

Another theme in the existing literature on women in engineering is the potential importance (both for recruitment and retention) of presenting engineering as a more socially oriented profession in which practitioners could feel that they were helping people, improving the world, solving social problems, etc. Prieti (2017) conducted a small, interview-based study with 16 engineers (four of whom were women) employed in the “alternative energy” sector in Germany and Austria that shows how difficult this sort of presentation may be to achieve. Although the alternative energy sector is widely seen as “altruistic” (and sometimes feminine), she found that engineers employed in this sector tended to play down the alternative characteristics of their work and to emphasize that they were doing mainstream, professional engineering work. They largely rejected more romantic notions of how one should interact with nature, stressing instead that engineering interacts with nature as a resource. Despite the sector’s appearance as alternative, women were underrepresented in the engineering labor force in these fields. In other words, there is no simple correspondence between the public perception of a field as more altruistic or communal and its attractiveness to female engineers. Similarly, engineers (including women) employed in these sectors do not appear to embrace alternative definitions of what engineering practice should mean.

Blair-Loy and Cech (2017) report on a very interesting investigation of the issue of “overload” among women researchers and professionals in science and technology industries. Overload has long been identified as a problem for female professionals, including engineers, and the suspicion has long been that this may be a factor pushing some women out of the engineering workforce. Blair-Loy and Cech find that a “work devotion schema” is widespread in science and technology — undivided devotion to work is defined, by many, as a valued end. Women who embrace this schema are much less likely to experience overload, even when compared to others who have similar work and family conditions but embrace the schema less. The work devotion schema appears to be a powerful force making intensive work demands seem reasonable and manageable. However, the schema is less effective for mothers of young

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Sexual harassment and sexual abuse by powerful men made headline news throughout 2017. The emergence of the #MeToo movement and a series of revelations of sexual misconduct by prominent men — ranging from Harvey Weinstein to John Conyers, to Kevin Spacey to Al Franken to Roy Moore — made the frequency with which women experience harassment and abuse apparent to the general public. The high-profile cases involving politicians and media figures concentrated attention on those industries and, to an extent, drew attention away from the tech industry, which had been in the headlines in 2016. Still, revelations about sexual harassment and abuse in the tech sector continued in 2017 and, along with it, a sense that tech was often a hostile environment for women continued to grow.

Early in 2017, Susan Fowler, an engineer formerly employed by the ride-sharing company Uber, went public with her allegations that she had been sexually harassed by her manager and that the company had been reluctant to take action in response. This was followed by other revelations about sexual misconduct at Uber, including reports that senior employees had visited a karaoke bar in Seoul known for its escort services and reports of a mishandled rape investigation. Former Attorney General Eric Holder was brought in to lead an internal investigation. A series of firings and resignations followed, culminating in the resignation of the company’s chief executive and co-founder, Travis Kalanick, in June.

The Uber case drew increasing attention to the Silicon Valley and the startup world, leading to a series of scandals involving emerging tech firms and venture capitalists. Concerns about sexual misconduct in tech startups go much further back than 2017, but this year there were a number of well-publicized accusations of sexual assault and harassment made by women involved in start-ups and/or venture capital firms in the tech sector. Several prominent men resigned as a result, including Kris Duggan, who resigned as the CEO of BetterWorks; Justin Caldbeck, who resigned from Binary Capital; and Dave McClure, who stepped down as general partner at the company he helped found, 500 Startups.

Google also was embroiled in the controversy about the sexual culture in tech. In December, Google suspended Steven Scott, Ph.D., senior AI researcher, who had been accused of sexual harassment and groping by a female employee in data science. Reports that Scott had engaged in such behavior previously, and that there had been no consequences, subsequently appeared in mainstream media outlets. Google also found itself in the news for other, gender-related reasons. Four former Google employees brought a class action suit against the company for its alleged discriminatory pay practices (a similar suit had been dismissed late in December). The increasingly tense sexual politics of the tech sector were epitomized by the fact that, almost at the same time, a class action suit was brought against Google by male employees, led by James Damore (a software engineer fired over a controversial essay on diversity) and former software engineer David Gudecan, Ph.D., alleging that the company discriminated against white men and conservatives. And, Tesla, which was the subject of sexual harassment complaints at various times during 2017, fired a female engineer, AJ Vandermeiden, who had complained of sexual harassment and unequal pay, allegations the company claimed were unmerited.

Ellen Ullman, a pioneering female programmer in the computer industry, has written that, when asked why she left engineering for consulting, she replied, “Excuse me ... but I’m afraid I find the engineering culture very teen-age puerile.” (p.13) and recounted how she “look[ed] around at the boys with beer bottles, the culture of very young men I had been pleased to leave.” (p. 102) Ullman’s characterizations of the culture of the tech industry are probably more charitable than some might make today, but she draws attention to what appears to be a male-dominated culture in which sexual harassment and misconduct are able to thrive and in which it is difficult for women to obtain justice and equal treatment. A significant article by Sheelah Kolhatkar, published in The New Yorker in November, argues that the tech industry is typical of industries in which males are the overwhelming majority and dominate leadership positions — the tone is set by the male majority, and women find that their problems are not understood and that they are largely powerless. The problems are compounded by the fact that start-ups often begin as informal groups of young men without clear rules. They often lack HR departments that could receive complaints about employee misbehavior or discriminatory practices. The sector also prides itself on its commitment to social improvement, making it harder to acknowledge the internal injustices that complaints about sexual misconduct reveal.

In some respects, 2017 may have given women in the tech sector reasons for optimism. Like the broader #MeToo movement, the fact that sexual misconduct in the tech industry is being revealed and discussed publicly, and that at least some of the men involved have had to resign, moves the problem from the shadows into the light. At the same time, it is clear that much remains to be done before the tech sector becomes a welcoming place for interested female employees. Even in the interview process, tech companies’ male cultures come through in the form of comments about how female candidates aren’t a good cultural fit, and through the emphasis on perks such as ping-pong tables and company parties, without a corresponding emphasis on family-friendly policies and lactation rooms. Women such as Aj Vandermeidyn run the risk of losing their jobs if they complain too vigorously. A recent article in The New Republic asks why scientists accused of sexual misconduct are not ineligible for federal grants — the government still lacks a mechanism for dealing with situations where a grant recipient or potential grant recipient is the object of sexual misconduct allegations.

So, while more attention is being focused on the problem, and while, as Kolhatkar notes, there are growing numbers of ways for women to share their experiences and support one another, the tech sector and its culture remain male-dominated and the revelations of widespread sexual misconduct reinforce the view that the sector is not a welcoming place for female employees. The chicken/egg dilemma thus remains: It will be difficult to attract women to the tech sector (and to retain them) as long as it is dominated by a male culture rooted in gender imbalance; but, it will be difficult to uproot and change that culture until more women enter the field.

Sources:
5. Bart, J. “Sexual Harassment Scandals Have Been Rocking the Tech Industry — But We’ve Seen All This Before.” Business Insider, August 2, 2017.
and school-aged children. For them, a different schema, a cultural mandate of family devotion, pushes against the work-devotion schema. If women are supposed to care for children, undivided devotion to work becomes problematic. Blair-Loy and Cech’s study provides some support for the view that work/family conflict and feelings of overload may be encouraging some female engineers to choose between work and family obligations. At the same time, the authors note a troubling implication of their findings: The fact that many women embrace the work devotion schema enables them to commit to long hours and sustain a set of organizational demands that other women (and some men) may find difficult to sustain. In other words, it tends to normalize a set of work expectations that only some women (and men) are willing and able to meet.

Obviously, there are many questions about labor markets and workplaces that this small group of publications does not address. Among the issues not taken up in this year’s literature is the question of the earnings gap — how do female engineers’ earnings compare with men’s and, if there is a gap, what accounts for it? The question of earnings inequality is implicit in studies such as Fernandez and Campero’s analysis of the lack of women in senior roles, but they do not take it up explicitly. Goldin et al. (2017) suggest a direction for future research on engineers’ earnings might take. They examine the gender pay gap among college graduates and ask whether it is the result of the fact that women are less able to experience upward mobility within organizations (a question related to Fernandez and Campero’s study), or whether it is because they have less ability to move from low-wage to high-wage firms (perhaps because of family commitments). They find that both factors matter, with upward mobility within organizations being somewhat more important. It would be interesting, and important, to learn whether this general phenomenon is present in the specific case of engineers.

**FEMALE ENGINEERS IN THE ACADEMY**

As in previous years, we reviewed several papers focused on the experience of female engineers in universities. Perhaps because of easier access to respondents, perhaps because of the availability of funding through programs such as the National Science Foundation’s ADVANCE, many academic researchers interested in what happens to female engineers after they earn their degrees have concentrated on understanding the academic sector.

One concern in this literature has been the question of recruitment. Do female graduates of engineering programs have equal access to opportunities for academic employment? Two studies we reviewed this year considered interesting aspects of this question. Blair-Loy et al. (2017) examined data from video recordings of 119 job talks given by applicants to departments in nationally ranked engineering programs in two American universities. Of particular interest is the fact that they were able to concentrate on applicants who made it to the short list — they were invited for a job talk so were being seriously considered by the hiring department. They found that female presenters faced more questions, were asked more follow-up questions, and spent a higher percentage of their time listening to audience speech. This was true at all levels, although senior applicants generally encountered fewer questions than junior ones. Blair-Loy et al. note that they don’t know which candidates received job offers, but they argue that there is evidence in their findings that female candidates face more scrutiny and, thus, may be at a disadvantage when applying for positions in engineering programs.

Pinheiro, Melkers, and Newton (2017) examine another aspect of the hiring process — the interaction between job candidates’ preferences, the institutions from which they came, and the actual placements they obtained. They obtained their data from the NSF-funded NETWISE II project; their sample included 2,670 STEM faculty members in the United States. Unsurprisingly, they found that candidates’ preferences had a lot to do with where they found employment — those who preferred a teaching institution were far less likely to obtain positions in research universities. The authors also found important gender differences in the roles played by advisor support and the prestige of the institutions from which they received their degrees. Advisor support was crucial to obtaining a position at a research (but not a teaching) institution, but women benefited in this way only at master’s-level institutions. Men benefited in all research-intensive jobs. In addition, the prestige of the doctoral institution functioned differently for men and women, with men benefitting when they applied to research institutions while women...
benefited only at liberal arts schools. These results point to one of the mechanisms by which women may be tracked into different kinds of academic employment than men.

This year’s studies of female engineering faculty also considered career patterns after the initial hire. Bagues et al. (2017) examined data from two evaluation committees, one in Italy and one in Spain, involving in qualified scholars to be promoted or hired at the level of associate or full professor. They found that the presence of female evaluators on the committee had little effect on the success rate of female candidates and, in fact, that committees with more significant female representation tended to be less favorable to female candidates, while all-male committees were more favorable to women than gender-mixed committees. Some of the data from this study draws are relatively old (the Spanish data are from 2002–2006). Still, these surprising findings suggest that increasing female representation in the promotion review process may not always produce the intended outcome.

Evidence that some women leave academic engineering after finding an academic job appears in a study by Gumpertz et al. (2017). Using data for all tenure track associate and assistant professors at four research-intensive, doctorate-granting, large land-grant universities, the authors found that, in the most recent cohort (2002–15), female assistant professors were more likely than men to leave the institution without tenure in engineering, but not in other STEM disciplines. In contrast, the mean time to promotion from associate to full professor was similar for women and men in engineering, but longer for women in biological and biomedical sciences. If this relatively small-scale study were replicated at the national level, it would provide important evidence that women who leave academic engineering do so in the earlier portions of their careers.

Finally, several studies we reviewed this year examine research activity by women; given the importance of research productivity to career progress in academic engineering and science, many researchers have examined whether there are differences between men and women in this regard. Baker (2017) summarizes the results of an analysis of data mined from the journal publisher Elsevier’s Scopus database. The analysis shows the numbers of female researchers increased between the periods the study compared, 1996–2000 and 2011–2015, with improvements in almost all disciplines. Although the gender gap remains large in fields such as engineering, it has narrowed in the period under review. Overall, women publish less than men, but when normalized for subject area and other factors, a field-weighted citations impact index showed no significant difference between men and women. Female author publications were downloaded more frequently than their male counterparts in all countries studied. All of this represents encouraging evidence that female academics in STEM fields are increasingly active researchers and that their work is achieving recognition.

Scientific collaboration is another area of interest for scholars interested in women’s status in academic engineering and science. Because research in STEM fields is so frequently collaborative, and because access to resources such as grants and equipment depends on having a network of active collaborators, faculty who collaborate less are at a disadvantage in being productive researchers. Do women collaborate as much or in the same ways as men? Araújo et al. (2017) used data from the Lattes Platform, an information system maintained by the Brazilian government, to examine the collaborative networks of scientists in eight major fields, including engineering. They found that men collaborate more with men, while women collaborate more evenly with both genders. Engineering appears different, however, as the larger number of collaborators in that profession tends to even out these gender differences. Women were also more likely to collaborate across disciplines. The authors offer no analysis of how this may affect careers, but these differences in collaboration merit further investigation.

Forthcoming Special Issues of Interest

We are aware of several special journal issues to be published in 2018 and beyond that may be of interest to readers. (There certainly may be others about which we are unaware, and any omissions are unintentional.)


INTERSECTIONALITY

Over the past few years, we have noted in the literature review a small but growing recognition of the importance of intersectional gender research — that is, research exploring multiple, intersecting facets of identities, such as gender, sexuality, race, and class. This year we were pleased to see not only a continued upward trend in the number of papers engaging with intersectionality, but also advances in the type of work being done. Those advances were both conceptual and methodological.

On the conceptual side, we saw greater engagement with a broader range of intersectional issues beyond race or ethnicity, notably nonbinary gender and sexuality. For example, we reviewed an ASEE paper by Rhode, Kirn, and Godwin on nuanced gender identities that suggested students who identify as cisgender (that is, someone who identifies with the gender they were assigned at birth) could play a role in helping noncisgender students (that is, students who identify as trans...
2017 Outstanding Women in Engineering
By Marc Lewis

The National Academy of Engineering (NAE) Awards
NEW FEMALE MEMBERS
Ellen M. Arruda, Ph.D., University of Michigan
Cheik A. Acakwa, Ph.D., International Business Machines Corporation
Cleopatra Cabuz, Ph.D., Honeywell Industrial Safety
Dianne Chong, Ph.D., Boeing Research and Technology (Retired)
Andrea Goldsmith, Ph.D., Stanford University
Selda Gunesl, Ph.D., Royal Dutch Shell PLC
Paula F. Hammond, Ph.D., Massachusetts Institute of Technology
Julia Hirschberg, Ph.D., Columbia University
Jennifer R. Holmgren, Ph.D., LanzaTech
Kathleen Connor Howll, Ph.D., Purdue University
Dina Katabi, Ph.D., Massachusetts Institute of Technology
Ruby Leung, Ph.D., Pacific Northwest National Laboratory
Jennifer A. Lewis, Sc.D., Harvard University
Tsor-Jee Liao, Ph.D., University of California, Berkeley
Deb A. Nienaber, Ph.D., University of California, Davis
Sarah Slaughter, Ph.D., Built Environment Coalition
Megan Joan Smith, Former U.S. Chief Technology Officer and assistant to the President
Darlene Solomon, Ph.D., Agilent Technologies
Susanne M. Vautrinot, Kilovolt Consulting Inc.
Katherine Anne Yelick, Ph.D., University of California, Berkeley

SUZANNE JENNIFICHES UPWARD MOBILITY AWARD
Endowed by Northrop Grumman Corporation
Denise C. Johnson, Caterpillar Inc.

RESNIK CHALLENGER MEDAL
Terri Taylor, Honeywell Aerospace

WORK LIFE INTEGRATION AWARD
Cindy Hoover, Spirit AeroSystems

DISTINGUISHED ENGINEERING EDUCATOR
Deborah O'Bannon, Ph.D., P.E., FSWE, University of Missouri–Kansas City

ADVOCATING WOMEN IN ENGINEERING AWARD
Imelda G. Castro, Intel Corporation
Heidi Millard Kenkel, John Deere
Coris Murray, Abbott
Cynthia Reid, P.E., LORD Corporation

GLOBAL LEADERSHIP AWARD
Maryann Combs, General Motors
Karen Ramsey-Idem, Ph.D., Cummins Inc.
Liz Ruetsch, Keysight Technologies

GLOBAL TEAM LEADERSHIP AWARD
Intel Corporation Global Water Conservation Team

PRISM AWARD
Joan Chinnery, P.E., The Boeing Company
Lisa Depew, McAfee
Colleen M. Layman, P.E., HDR Inc.
Leslie M. Phinney, Ph.D., Sandia National Laboratories
Anna Prakash, Ph.D., Intel Corporation

SPARK AWARD
Marie S. Cole, IBM Corporation
Mary Driver, Lockheed Martin Corporation
Beverly Louie, Ph.D., University of Colorado Boulder
Lynn Mortensen, Raytheon Company (Retired)

HEATHER SAVAGE-Erickson, Medtronic

EMERGING LEADER
Niki C. Bahk, Siemens
Eri M. Carroll, Intel Corporation
Jill A. Entner, Torrance Refining Company, LLC, a subsidiary of PBF Energy Inc.

Kelly D. Hahn, Ph.D., Sandia National Laboratories
Christine M. Predaino, Northrop Grumman Corporation
Jennifer Rech, Honeywell Aerospace
Meeneshi Shafe, The Boeing Company
Shannon Vittur, Medtronic
Justynda Zander, Ph.D., NVIDIA Corporation
Kira Zdunek, Caterpillar Inc.

SWE DISTINGUISHED NEW ENGINEER
Maria Cecilia de Castro Breda, John Deere
Stephanie W. Chin, Intel Corporation

DIFFERENTIATING SERVICE AWARD
Susan Thomas Schlett, Sikorsky Aircraft/Trinity College

OUTSTANDING FACULTY ADVISOR
Diane L. Peters, Ph.D., F.SWE, FNAE, University of Illinois at Chicago

A. RICHARD NEWTON EDUCATOR AWARD
Stephanie DeCotiis, P.E., H2M

NATIONAL SOCIETY OF BLACK ENGINEERS (NSBE) GOLDEN TORCH AWARDS

Dr. Janice A. Lumpkin Educator of the Year
Major Delante Moore, United States Military Academy

PRE-COLLEGE INITIATIVE STUDENT OF THE YEAR (FEMALE)
Audra Collins, San Antonio City Wide NSBE Jr. Chapter

OUTSTANDING WOMAN IN TECHNOLOGY
April Fowles, Northrop Grumman Corporation

GRADUATE STUDENT OF THE YEAR
Rachel Harsley, Ph.D.(c), University of Illinois at Chicago

PROFESSIONAL MEMBER OF THE YEAR
LaShara Smith, Tredgear Films Productions

Society of Hispanic Professional Engineers (SHPE) Awards
COMMUNITY SERVICE
Samantha Dominguez, Lockheed Martin

INNOVATOR AWARD
Olivia A. Greene, University of California, San Diego

JUNIPERO SERRA AWARD
Maida Lopez, The Boeing Company

PROFESSIONAL ROLE MODEL
Maria Garcia, Honeywell

SHPE STAR OF TOMORROW AWARD
Maria Cecilia de Castro Breda, John Deere

SWE STATE OF WOMEN IN ENGINEERING 2018
or agender, genderqueer, or gender fluid) develop a sense of belonging in engineering. That paper also includes important information on how to make demographic sections of surveys more inclusive of a larger number of gender identities.

Another paper that conceptually advanced intersectional research on gender and sexuality was Alfrey and Twine’s “Gender-Fluid Geek Girls,” which appeared in Gender & Society. This workplace study describes a “spectrum of belonging” in which demographic sections of surveys more inclusive of LGBTQ and gender fluid face fewer microaggressions, have a greater sense of belonging, and are perceived as more competent than conventionally feminine, heterosexual women. Alfrey and Twine argue that this spectrum of belonging for women reinforces inequality regimes that privilege male workers.

Methodological advances included the development and testing of new survey instruments designed to better examine the experiences of women of color in engineering. One survey, by Cross, Clancy, Mendenhall, Imoukhuede, and Amos, is called the “Womanist Identity Attitude Scale” and was created from a combination of the most relevant previously published and validated scales in order to obtain a holistic instrument for investigating the experiences of women of color. Preliminary findings included that women of color in engineering programs had different experiences than other women students. A second survey, titled “The National Survey of Women Engineering Faculty,” by Cox, Kim, Sanchez-Pena, Main, and McGee, was created to understand why and how faculty women of color persist in engineering. This survey is a wholly original instrument that is currently being validated and pilot tested. Both of those survey instruments represent important advancement in intersectional gender engineering research. They were described in ASEE papers, and we look forward to seeing findings that emerge from the new instruments in journal articles in the coming years.

Additionally, in the set of papers exploring intersectionality (in addition to other topics) this year, two ASEE papers built on prior critical content analyses (e.g., Beddoes and Borrego, 2017; Pawley, Schimpf, and Nelson, 2016) in important ways. First, Artilles, Waters, Taylor, Boyd-Sinkler, Williams, Hampton, Hermundstad, Lee, and Lutz examined more than 150 diversity papers from ASEE 2015 and 2016. They found that intersectionality was underexplored and that, as a community, we need to create “intersectional spaces” where such work can flourish. They also conclude, as others have (e.g., Beddoes, in press; Beddoes, Borrego, and Jesiek, 2009; Pawley, Schimpf, and Nelson, 2016), that diversity research needs to move beyond problematizing underrepresented groups: “The most common profile of the publications in our sample is researchers answering how a specific, diverse demographic is different from the majority in an academic engineering context through the use of surveys and interviews as the main data sources for the purpose of recruitment and retention of such diverse groups. While the question being pursued are warranted, through this work we exhorted the community of engineering education researchers to expand the profiles of their work into the questions, demographics, and contexts described in our discussion as being understudied” (p. 12).

Another theme in the existing literature on women in engineering is the potential importance (both for recruitment and retention) of presenting engineering as a more socially oriented profession in which practitioners could feel that they were helping people, improving the world, solving social problems, etc.

Another very interesting exploratory study of 18 female technology workers in the greater San Francisco area (Alfrey and Twine 2017) points to the challenges women face in fitting in to a male culture in the tech industry. Alfrey and Twine’s respondents described a “geek culture” that shaped the environment in which they worked, affecting a wide range of things, including dress, expected cultural knowledge, interests, and so on. Employees in the tech industry needed to fit in to this culture if they were to be accepted and successful. The female employees who were successful in this area (Alfrey and Twine 2017) also reported that different sorts of women had different levels of success interacting with this culture. White women whose self-presentation was “gender fluid” and who identified as LGBTQ were better able than others to manage their status on male-dominated teams. Race mattered, however, as black women who did the same were not as successful. Conventional feminine women also had less success “fitting in” to male-dominated teams. They reported experiencing a range of micro-aggressions in their interactions with male co-workers. These ranged from relatively minor
things such as the failure to make eye contact or more aggressive questioning, to more serious experiences of actual aggression. Reading about Alfrey and Twine’s respondents, one begins to get a glimpse of the cultural environment that produces the incidents of sexual misconduct about which we have all begun to learn. Fitting into that culture is clearly difficult for many women, so it should not surprise us that many either choose not to enter or decide to leave when they find they are unwelcome.

At the same time, a very interesting article by Dana Britton (2017) reminds us that tackling the hostile culture or “chilly climate” in STEM fields such as engineering will be quite complex. Britton interviewed 102 female faculty members in STEM fields on 13 research-intensive public university campuses in the U.S. between 2009 and 2010. Her research examines an important paradox: While there is abundant evidence of a chilly climate in the academy for women, of unequal treatment of female faculty, many women faculty members say they don’t feel it. Britton found that many female faculty members tended to minimize the importance of gender in interactions with their colleagues, perhaps fearing that doing otherwise would draw attention to their gender and cause them to be treated as “tokens” whose success was attributed to that status. Female faculty members acknowledged incidents of unfair and unequal treatment, but didn’t see them as part of a broader, “chilly” climate. Britton summarizes her findings as follows: “Overall, these interviews indicate that the resistance among many women faculty to seeing their workplace climates as ‘chilly’ is grounded in the fact that this metaphor, with its implication that gender is both systematic and pervasive, does not fit their understanding of how gender matters at work.” (p. 23)

Britton’s respondents, for the most part, did not report the kinds of egregious mistreatment that contemporary media reports have described in the tech industry. One could argue that it is easier to play the gender card when one experiences it only in milder forms. Nevertheless, Britton’s study is a useful reminder that the experience of mistreatment is not the same thing as the perception that it is part of a larger systemic problem. It is quite possible to regard even a serious experience of sexual harassment or sexual violence as the action of a single person, the proverbial bad apple, and not connect it to anything broader. In short, demonstrating the existence of a hostile culture or chilly climate in the tech sector or in engineering will require going beyond reporting on incidents of abuse. Research will have to show that those incidents are not unusual and that they are connected to a broader set of values and behaviors in which they thrive. Further, combating that culture will require convincing not just men, but women, that there is in fact a cultural (not individual) problem to be addressed and persuading them to tell their stories and define their experiences as a consequence of that broader culture. Britton’s study indicates that this won’t happen automatically. And, it underlines why journalistic reports of individual incidents must be bolstered by systematic research on the culture of engineering and STEM.

About the authors

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References

The following comprise all of the noteworthy articles and conference papers found in our search of the 2017 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 readers’ convenience, we have included the complete list of materials we consulted.


How can we encourage more girls to consider engineering as a career? Studies indicate that, while many girls express interest in STEM at a young age, girls’ attitudes shift in the tween years (ages 8 to 12), leading to far fewer female high school graduates choosing to major in engineering programs in college compared with their male counterparts. Research indicates that students who hold STEM career aspirations at age 14 are 3.4 times more likely to enroll in a STEM program in college, which suggests that efforts to encourage and maintain middle-school girls’ interest in STEM may lead to an increase in gender diversity in these professions.

The messages transmitted to tween girls can have a great impact on their interest and awareness of engineering as a desirable profession. The Society of Women Engineers recently conducted a literature review to identify effective messaging strategies that would encourage girls ages 8–12 years old to consider becoming engineers. The review included research around four specific areas, including the influence of media on reinforcing gender stereotypes, messaging about the engineering profession, market research on tween girls, and studies of effective messaging strategies.

The analysis of available research and current messaging strategies resulted in a number of observations. First, messages that combat negative stereotypes and offer examples of female engineers with diverse interests and backgrounds can have a positive impact on tween girls’ interest in engineering. Early exposure can help young girls and tweens see themselves in such roles in the future, and the media can serve as a conduit for providing access to role models.

Second, messages that convey engineering as a way to help people or to contribute to societal improvements can positively influence girls’ interest in the profession. Research has shown that girls are more inclined to hold humanistic values, and they may not see engineering as a profession that helps people. Media that show engineers and STEM professionals in ways that emphasize the impact they can have on society can be particularly powerful.

Third, messages should include a diverse representation of messengers. Girls of color are particularly responsive to seeing diverse role models. By ensuring that messengers do not embody STEM stereotypes, but instead present relatable messengers, media can promote the inclusiveness of the engineering culture.

Fourth, messaging strategies that combine scientific learning and social networking have been effective in engaging tween girls. Tween girls want messaging that is authentic and relatable, but also shareable.

Many programs and activities aimed at increasing girls’ interest in STEM, and engineering in particular, exist, but little research is available to understand the impact these efforts have on encouraging girls to become engineers. The research on the negative impacts that stereotypes about engineers and engineering portrayed in the media can have on girls’ interest in STEM is useful; but to ensure that our direct efforts are having positive results in combating these stereotypes, more research is needed to determine the effectiveness of messaging specifically designed to increase girls’ interest in engineering, particularly among girls from diverse backgrounds.

To download a copy of the report, please visit https://research.swe.org/swe-research/. This research was funded by the National Science Foundation under Award #1548200.
What if colleges and universities were rated by their efforts to ensure diversity — much like buildings earn tiers of LEED (Leadership in Energy and Environmental Design) certification?

Just such a program, called “STEM Equity Achievement (SEA) Change,” has captured the interest of 10 U.S. colleges and universities, which are setting up a trial run. Shirley M. Malcom, Ph.D., director of education and human resources programs at the American Association for the Advancement of Science, said the initial participants range from small colleges to top-tier universities. She declined to name them, saying that at this stage, it’s an experiment.

Yet already, a SEA Change analytics subcommittee is studying the best ways to create reasonable metrics for a “bronze” award — the first level of the certification program, said Dr. Malcom, renowned for her 1976 co-authorship of “The Double Bind: The Price of Being a Minority Woman in Science.”

The bronze award is the entry phase of a similar program that started in the U.K. in 2005, called Athena SWAN (Scientific Women’s Academic Network), established and managed by the Equality Challenge Unit, a charity that describes itself as providing “a central source of expertise, research, advice and leadership. We support universities and colleges to build an inclusive culture that values the benefits of diversity, to remove barriers to progression and success for all staff and students, and to challenge and
change unfair practices that disadvantage individuals or groups.’

The SEA Change program, designed for the United States, would differ from the gender-focused Athena SWAN by measuring racial and ethnic diversity, as well as gender diversity. Dr. Malcom said.

ESTABLISHING CRITERIA AND A PROCESS

The American Association for the Advancement of Science would grant the awards based on panel reviews against established criteria. To earn a bronze, and to work up to a silver or gold level, U.S. colleges and universities would set up internal teams to determine the diversity and inclusion challenges they want to work on.

“They would begin a search for internal data that can say, ‘Where am I now as an institution?’” Dr. Malcom said. The process also would look at a more comprehensive picture. “We would encourage institutions to look at their data historically because that can reveal trends,” she said. “They would have to analyze the data and articulate a plan on how to address various data elements in the application process.”

Those elements would include the diversity of student and faculty populations. “Institutions are so different. Their definitions of what diversity is for them will be different,” Dr. Malcom said. “They need to be able to make a case that’s embedded in their own reality and their own contexts.” In addition, “They’re going to have to be able to convince [the SEA Change certifiers] that their expression of their goals will meet current needs, and that they are filling in the gaps where they are not performing well,” she added.

The SEA Change process would be more than just a numbers game, however. Colleges and universities also would have to look at their overall climates — the policies and practices that ensure their departments welcome gender, racial, and ethnic diversity, Dr. Malcom explained. In other words, the higher-education institutions would have to engage in self-reflection and then build structures to ensure they continue to improve their diversity efforts.

“Our overarching goal is a big goal: ‘Can [the college or university] become an institution that provides real opportunity for all the people who are there, no matter whether they are women versus men, or minority versus majority, or white versus African-American or Latino?’” Dr. Malcom said.

FUNDING IMPLICATIONS AND INCENTIVES

The pilot group of SEA Change colleges and universities is expected to develop materials to be reviewed for certification by late 2018, with ratings — bronze, silver, and gold — intended to be awarded by early 2019, she said.

Dr. Malcom said the SEA Change program hopes to follow Athena SWAN’s funding model by having the SEA Change ratings become important requirements for private funding donors.

“I would hope that private donors would see a value in being more open to funding research in places where productivity is likely higher and where they can take advantage of the innovation that emerges in more diverse settings,” Dr. Malcom said.

“When you start getting funders to say, ‘Shall we invest in a place that has dissonance, that hasn’t addressed harassment issues, that hasn’t looked at questions of the workplace environment, faculty of color, or different learners?’ That can clarify things for you pretty quickly,” Dr. Malcom said. “There is nothing that could prevent — and a lot to encourage — private funders to say, ‘Maybe we want to invest in healthy departments and get a better return on our investment.’”

Colleges and universities also could be incentivized by the kinds of ideals that drive architects and engineers to earn LEED certification, which identifies their buildings as energy- and resource-efficient, and as healthy places in which to live and work.

“I describe [SEA Change ratings] as LEED-like entry into the [SEA Change] certification process, which requires you to set goals for sustainability and inclusion,” Dr. Malcom said. “So, like LEED-certified buildings, the process may cost more than a conventional building to build. ‘So why would you want a LEED building?’ It may take you years to save the money that you otherwise would spend to design and build for LEED certification, but which you could recoup around energy savings,” she said. “The same kind of attitude prevails with SEA Change. One wants to declare one’s interest and commitment to a particular issue. In LEED, your interest is in the environment and your commitment to green building. It’s a prestige to have it. You don’t want to be the only one on your block without it. And often, tenants are interested in living in such a building.”

SEA Change certification also could prove a competitive advantage in attracting faculty, staff, and parents eager to see their children attend the highest-quality schools, Dr. Malcom said. When comparing college and university departments with and without SEA Change certification, which would parents prefer?

Taking the ramifications further, Dr. Malcom considered which type of institution a young faculty member would prefer to join. “At a place that’s hypercompetitive, living off of a 20th century reputation, or a place where there is awareness of a new reality — for a full career and buy-in for a culturally responsive pedagogy?” Dr. Malcom questioned.

Any college or university that earns SEA Change certification will be required to re-up after five years. “They’ll have to go back through the process,” she said. “That’s because inevitable changes in a school’s leadership, commitment, circumstances, programs, and departments can cause backsliding,” she said. “By putting these kinds of structures in place that call for recertification or re-examination or reassessment, you at least guarantee a level of attention and attentiveness that I don’t think you’d otherwise get,” Dr. Malcom said.

One of SEA Change’s challenges is fundraising, since its mission encompasses such a wider breadth than does Athena SWAN’s and, ultimately, many more higher-education institutions nationwide. “We have always realized that, in the United States, our diversity issues are so much more complex, and we are taking them on all at once,” she said. “We have real challenges — and they aren’t just about gender.”

For example, Dr. Malcom said colleges and universities tend to have inadequate data about students and others with disabilities. “There are other communities that need attention — such as first-generation students, who experience many of the same kinds of issues as students of color, and LGBTQ+ students, who experience similar marginalization,” she said. “The whole question about making this a safe and supportive space will bring in a bunch of students and faculty who are currently on the margins.”

THE INTERSECTIONAL SPACE

“If we’re not open to who we are and how we got to be where we are, it’s difficult for younger women to understand it’s OK to have doubts about STEM, to feel isolated and disenfranchised and a lot of other things,” Dr. Malcom said.

“We’ve been working since 1975 in the intersectional space involving women of color in STEM fields,” she added. “If you’re both a woman and a person of color, the experience you have in these fields is very different.”

Dr. Malcom should know. She was raised in segregated Birmingham, Alabama, just as the civil rights movement was unfolding. She attended a new, all-black high school that was built largely to relieve political pressure for a local white high school to be integrated, she said. When she graduated from Carver High School in 1963, Dr. Malcom had attended class in all-black schools with all-African-American teachers and principals.

Providing larger context, Dr. Malcom graduated from high school in Birmingham the same year as the racially motivated bombing of the 16th Street Baptist Church that killed four young black girls preparing for Sunday school, and nine years after the U.S. Supreme Court ruled in “Brown v. Board of Education” that state laws establishing separate public schools for black and white students were unconstitutional. Many colleges and universities maintained their segregated histories. That meant Dr. Malcom couldn’t have gained admission to schools close by because they were segregated.

“You had to go above the Mason-Dixon Line to find a research institution that was integrated,” she said.

Shirley M. Malcom, Ph.D.
BEYOND THE MARGINS

“So Dr. Malcom made the bold move to follow her sister and join an aunt and uncle in Seattle and attend the University of Washington. Her first-year dorm housed three African-American women out of 400 residents. By her sophomore year, Dr. Malcom was the only African-American woman in the dorm. “It felt very isolating, but on the other hand, it was what it was; this is what I chose,” she said. “I chose to study science. I was a pre-med major. I gave that up. It had a high-quality science program but wasn’t very diverse."

She majored in zoology and graduated in 1967 — along with a distinction of being the only African-American zoology major to graduate from the university in that class. When Dr. Malcom decided to go on to graduate school, she again chose zoology, and with her mentor’s recommendation, attended the University of California, Los Angeles. She earned her master’s in 1968. After teaching high school for a couple of years, she completed her Ph.D. in ecology in 1974 at The Pennsylvania State University (Penn State).

Dr. Malcom worked as an assistant professor at The University of North Carolina in Wilmington, North Carolina, for a year before she married and moved to Washington, D.C., where she said she “reinvented” her career. She headed the American Association for the Advancement of Science (AAAS) Office of Opportunities in Science from 1979 to 1989. Between 1977 and 1979, she served as program officer in the Science Education Directorate of the National Science Foundation. Yet it was still considered “strange” for a 28-year-old African-American woman to have a science Ph.D., she said.

RESEARCH AND TRENDS

“Beyond the margins”

“The point is that you had to find your own way,” Dr. Malcom said. “There weren’t any paths. I didn’t know anybody. I had to become something I had never seen.” She said she is still saddened to meet women of color who, these 43 years later, describe being that little girl from Birmingham who felt isolated to deciding to change, she said. “I had lived in a world of black and white all my life. Seattle was much more racially and ethnically diverse, with many different Asian populations and First Nations people because of Washington’s American Indian tribes.

“I came to understand that you didn’t have to be defined by your race or your gender,” Dr. Malcom said. “I was who I was. But that wasn’t all of who I was. In that process, I think, of self-discovery, as I acquired a science identity, I began to understand I was a lot more complex than a black girl who had left Birmingham in 1963.

“But Birmingham has never left me. I was totally shaped by that experience, which is why I am passionate about social justice; which is why I’m really concerned that America’s best self is not being realized with our current divisiveness,” she said. “In college, I met and got along with people who had very different experiences than I had had, but I was able to reach a point where I could call them friend.

“It set out a different kind of menu for what we can do and be. I’ve always been trying to work toward and aspire to that. That’s a much better state for everyone.” In the same vein, engineering and science cannot be their best selves without a commitment to diversity, Dr. Malcom said. “The other thing is I’ve also become, over time, much more aware that science and engineering need diversity. Their best selves are not being realized because of a lack of diversity.”

Dr. Malcom says that she is also driven by the work yet to be done. “You think about what we had to go through to develop research on women’s health; about what happens to women in developing countries who need innovations to improve their lives,” she said. “Without a corps of engineers, scientists, and technologists, who’s going to innovate on such important issues? We can do better than we have done.”

resources to do big things,” she said. “Now the foundation is committed to some bigger effort. Now, I think people are coming to understand that we can do things, but things don’t stay fixed.”

Though Dr. Malcom said she will always consider Birmingham her home, she appreciated how she changed by living in Seattle. “I went from being that little girl from Birmingham who felt isolated to deciding to change,” she said. “I had lived in a world of black and white all my life. Seattle was much more racially and ethnically diverse.”

Dr. Malcom said that she is also driven by the work yet to be done. “You think about what we had to go through to develop research on women’s health; about what happens to women in developing countries who need innovations to improve their lives,” she said. “Without a corps of engineers, scientists, and technologists, who’s going to innovate on such important issues? We can do better than we have done.”
REINFORCING BEST PRACTICES GLOBALLY

Athena SWAN branches out from its U.K. origins — the intersectionality of race and gender — to encompass best practices and strategic planning worldwide, and to take on additional issues at home.

By Sandra Guy, SWE Contributor

A program that rates universities on gender equality — and encourages funding sources to heed the results — is expanding beyond its U.K. roots and going digital. The voluntary system, called Athena SWAN (Scientific Women’s Academic Network), started in 2005 as a United Kingdom-based recognition initiative for women’s employment in STEM (science, technology, engineering, mathematics, and medicine) professions. It launched at 10 universities in 2005 and has since spread to 93 U.K. institutions and 556 departments within those institutions. Departments may earn certification only after the institution itself obtains one.

In 2012, Athena SWAN expanded to scientific research institutes, and in 2015, grew to cover the arts, humanities, social sciences, business, and law, as well as professional and support staff.

It relies on universities supplying assessments to the Equality Challenge Unit (ECU), a nonprofit organization that judges the institutions on their inclusiveness and equality in hiring, promoting, and retaining female staff. The awards are valid for four years, at which time the awardees may reapply.

REINFORCING BEST PRACTICES

The Athena SWAN charter, which looks at the intersectionality of race and gender at the institutional level, is being expanded to include best practices and strategic planning worldwide to take on issues such as racial inequality.

The expansion comes as the ECU’s board voted Dec. 15, 2017, to merge with the Higher Education Academy (HEA) and the Leadership Foundation for Higher Education (LFHE). The newly merged agency will be renamed in the near future.

HEA is known for developing excellent learning and teaching protocols, and the LFHE for developing best-in-class leadership, management, and institutional governance. Together, they provide access to accreditation, training, consultancy, thought leadership such as guidance or policy discussion documents, and help bring together practitioners in communities of practice.

They also seek to bring together best practices from other countries and take the U.K.’s experience to them.

“The merger will bring together these functions and help us to build on areas of mutual interest,” said Tom Welton, D.Phil., dean of the Faculty of Natural sciences at Imperial College London.

One example is the U.K. higher education’s racial attainment gap, in which black and ethnic minority students are less likely than men to voice their desires for policy changes, Dr. Welton said. “You have to look at your procedures. For example, do your promotion procedures reflect the policies you have designed for inclusiveness, fairness, diversity?”

It’s important to do so because women generally are less likely than men to voice their desires for pro-

EXAMINING THE INSTITUTION

Athena SWAN’s application forms seek data and evidence in four areas that Athena SWAN deems potential barriers to everyone’s career progression: recruitment, training, promotions, and an organization’s culture, said Sarah Dickinson Hyams, head of Equality Charters for the Equality Challenge Unit, including Athena SWAN.

“We look at management structures; at a number of ways that institutions enable career development — opportunities, appraisals, and performance development reviews, for example; and flexibility in managing one’s career breaks such as maternity and paternity leave and nursery provisions,” Hyams said.

The equality overseer uses panels of volunteer scientists to review and judge the applications. Of the latest round of 143 applicants in April 2017, 60 percent (85) succeeded in achieving an award.

The award levels of bronze, silver, and gold identify the achievement levels that a university or department has fulfilled.

- The bronze award shows that the institution has identified issues and challenges and has started planning activities to address them.
- The silver shows that the institution’s efforts have demonstrated evidence of impact and achievement.
- The gold spotlights a significant record of activity and impact and serves as a beacon for gender equality and good practice.

One gold-winning department — the chemistry department at Imperial College London — took several actions to ensure a welcoming atmosphere, including the seemingly simple step of starting a voluntary Friday departmental get-together over doughnuts, Dr. Welton said.

“It costs almost nothing, maybe 20 pounds a week,” he said in a telephone interview. “Not everyone has to go every week. But it helps oil the wheels of the department in feeling more welcoming.”

Another key to the Athena SWAN gold — a status signifying expertise worthy of advising others — is implementing policies that make change.

“All organizations will have wonderful policies that have never seen the light of day and have only been kept in a drawer,” Dr. Welton said. “You have to look at your procedures. For example, do your promotion procedures reflect the policies you have designed for inclusiveness, fairness, diversity?”

It’s important to do so because women generally are less likely than men to voice their desires for pro-

IRELAND

Athena SWAN started a pilot project in 2014 in Ireland.

Trinity College Dublin and the University of Limerick received the first Athena SWAN bronze awards from outside of the U.K. In July 2015. Since then, three more universities and six departments have earned bronze awards.

To keep the program growing, the Equality Challenge Unit renewed a three-year agreement with Ireland’s Higher Education Authority. The next deadline to submit for the awards is in September.
motions. “That can lead to a lag in the careers of women who don’t step forward,” Dr. Welton said.

As a result, the Imperial College London department’s managers review all their employees’ work annually and ask themselves whether each might deserve a promotion.

Such inclusive procedures govern recruitment, employee support, and workplace practices.

The recruitment process was formerly handled with a general advertisement but now requires everyone involved to undergo unconscious bias training and an active process of looking for diverse and highly qualified prospects. “We go and look for people with prestigious national junior fellowships, for example,” Dr. Welton said. He said other insights led the university to:

• Ensure that advertisements are worded in an open way and omit language that’s off-putting.
• Describe the position’s attributes in a way that’s gender neutral and unbiased toward any group.
• Separate job searching from job selecting. “It prevents me from tapping a favorite postdoc and saying, ‘Oh, I can offer you a job.’ That’s wrong.”
• Invite prospective employees to visit. Though the chemistry department has yet to recruit anyone into senior staff positions since it implemented Athena SWAN, it has hired four women onto its junior staff, reflecting a roughly 50-50 gender split in recruitment.

Dr. Welton also advised:

• Don’t try to save the world. Do the small things you can do.
• Empower people in your organization.
• If initial efforts fail, that’s OK; we’ll work it out. Don’t have a place where failure is a disaster.
• A feeling of inclusiveness must extend beyond management.

“On a Tuesday morning, as I walk through the department, what things are happening to make it feel welcome to me?” he said. “In the long run, the add-up to those hundreds of tiny little things makes a difference. It’s vital you don’t ignore them.”

“You can empower anybody to do those small things — not just managers,” Dr. Welton said.

Ten years ago, Dr. Welton was department chair when, separate from the Athena SWAN program, he and his colleagues reviewed their strategy with an eye to increasing the diversity of the largely white male department.

“It was around a business model idea: We went through a process of defining what it would be to be the best chemistry department. Part of the definition was that we’d be where the best chemists would want to come and work and study,” he said. “The primary driver wasn’t fairness or being nice to people. It was, ‘Oh, hang on, our lack of diversity is telling us we’re not achieving what we want — being the best chemistry department.’”

ASSESSING IMPACTS

By establishing a more collaborative work environment, Athena SWAN has prompted concrete results. In a 2016 survey, nearly 90 percent of U.K. academics who were aware of Athena SWAN believed the program’s initiatives had a positive impact on the work environment. The Athena Survey of Science, Engineering and Technology (ASSET) revealed that even among those who saw the Athena SWAN program as paying “lip service” to gender equality had seen specific instances of its effectiveness.

The survey, conducted by the Equality Challenge Unit (ECU), quoted one unnamed female professor in the nursing and allied health professions as saying, “However, I have a friend who only got promotion to chair (20 years late) when access to key funding streams was linked to Athena SWAN — she was fast tracked. So perhaps this is the approach, when it is linked to funding it is the bottom line that focuses the minds of the institution.”

The ECU’s 2014 internal evaluation report found in the institutions that had earned awards, the staff reported greater career opportunities and a sense of belonging, according to Sarah Dickinson Hyams, head of Equality Charters for the ECU. For institutions that had earned silver status, the support staff reported an enhanced feeling of belonging.

The Roslin Institute, the only institutional gold award recipient so far, increased the percentage of female professors from 22.7 percent to 35 percent in the time it worked with the Athena SWAN program. The institute is one of the National Institutes of Biotechnology and is part of The University of Edinburgh’s College of Medicine and Veterinary Medicine.

Jane Norman, M.D., vice principal of equality and diversity at The University of Edinburgh, said the Athena SWAN process made the university realize it wasn’t telling people explicitly what they needed to do to earn a promotion.

“We expected people to absorb that information,” said Dr. Norman, who is director of the Edinburgh Tommy’s Centre for Maternal and Fetal Health and deputy director for reproductive health. As a result of working with Athena SWAN, the university held workshops to offer explicit directions for promotions and encouraged a broader swath of people to apply, she said.

The institute also offers shared parental leave so two partners can split their leaves and still get paid. The idea is to give partners more flexibility during the first year of their child’s birth or adoption. On the other hand, the institute also realized it has a gender pay inequity at the highest levels of academia — a situation that has no quick fix because the reasons are long-standing, Dr. Norman said.

As the institute renews its standing, it’s putting together an action plan and aiming to share practical examples of how people and institutions can make a difference for greater gender equity, she said.

At the University of Glasgow, which earned a silver Athena SWAN designation, academic returning to work from maternity or shared parental leave may apply for up to 10,000 pounds (~$14,000 U.S. dollars) in grants to help them resume their research.

The incentive, started in 2015, enables new parents to free up time for international travel and bring in international collaborators so their research doesn’t suffer, said Katie Farrell, the university’s gender equality officer. So far, more than 20 academics have obtained research grants at a total cost of more than 200,000 pounds (~$280,000 U.S. dollars).

The university, where four departments earned silver Athena SWAN designations, is still assessing the program’s impact.

The university also formalized its process for new staff and academics to obtain mentors who excel in the skills the new employees seek to improve. Farrell said.

Another step that boosted female response to an employment ad for the chemistry department was consolidating the essential criteria to make it clearer and more accessible, she said.

Farrell also recommends:

• Schedule research seminars and enable net-working during working hours so such events don’t turn into “old boys” situations.
• Avoid all-male or all-female panels at seminars and conferences.
• Create job-shadowing opportunities for early-career staff so they can serve on research committees and participate in decision-making.
• Let employees discuss their development at work and the kinds of skills they intend to achieve in the next two to three years.
• Require that members of promotion and recruitment panels take training in unconscious bias.
• Beware of nontraditional underrepresentation. For example, men are underrepresented in education and nursing.

AUSTRALIA

In Australia, the pilot Athena SWAN program now has 44 institutions, medical research, and publicly funded institutes competing for awards. The next round of applications is due March 2018. They’ll be assessed in July, with winners announced in September.

The pilot program runs until November 2019.
“The changes have made people a lot more mindful of intersectional and other considerations,” Farrell said. “The awareness has made people more thoughtful about other types of inequalities.”

Among other results, the University of Liverpool upped the percentage of women promoted to professorial positions from 28 percent to 50 percent between the time it earned a silver award in 2016 and its bronze award in 2013. Though most major U.K. funding councils recommend that institutions seek Athena SWAN certification, only government biomedical funding has been specifically linked to it. That occurred when Dame Sally Davies, the U.K.’s chief medical officer, declared that starting in 2015, medical schools could no longer be shortlisted for research officer, declared that starting in 2015, medical schools could no longer be shortlisted for research funding.

“Academic research is such a mobile occupation. Researchers go back to their home countries and realize there’s nothing like [Athena SWAN] — so they put pressure on their institutions and government to set up something. All of it is done by the community for the community,” Hyams said.

India

A November 2016 report co-authored by the Indian National Science Academy, Summary Report: Women in STEMM India Workshop, recommended the country adopt Athena SWAN in part because Indian women scientists are looking at implementing measures at an institutional level to bring about gender equity in STEMM careers.

Among those working toward India’s adopting its own version of Athena SWAN is Rohini M. Godbole, Ph.D., vice president of the National Academy of Science, India; chair of the Women in Science panel of the Indian National Science Academy; member of the joint Academy panel for Women in Science; and a professor at the Centre for High Energy Physics at the Indian Institute of Science, Bangalore. She said India’s higher-education institutions have to address silent, unconscious bias, and the country’s academies and institutions must work to increase the percentage of women in faculty and leadership positions.

“When you look at high-profile institutions, the percentage of women in academic and leadership positions in physics, for example, is less than 10 to 12 percent, compared with women’s 25 to 30 percent participations in the field,” Dr. Godpole said. “The target I’d love to see for physics institutions, for example, is to set women’s representation at 25 percent because that’s what it is in the overall Ph.D. population.”

Dr. Godpole also appreciates Australia’s requirement that some of the science institutions give gender sensitivity questionnaires to prompt people to think about their unconscious biases. Those who fall short in recognizing their biases must repeat the test and, only after they achieve a certain score can they access online material required to advance in the process.

“If half of the time, the barrier is people’s lack of thinking,” Dr. Godpole said. “It’s often very small things that people do or don’t do.”

There’s no set timetable yet for India to adopt an Athena SWAN–like program, because Dr. Godpole and others are working behind the scenes on the effort while maintaining other duties and conducting research.

Educational leaders also say they are partly motivated by the desire to do the right thing, according to the Equality Challenge Unit report. The Athena SWAN program shows similar progress worldwide (see sidebar). Regarding this global advancement, Hyams said Athena SWAN’s approach to expanding is “very organic.” She noted that, “We don’t go and look for different countries,” she said. “They approach us.” Other countries in talks or interested in joining Athena SWAN include Canada, Japan, New Zealand, Norway, and Sweden.

“Academic research is such a mobile occupation. Researchers go back to their home countries and realize there’s nothing like [Athena SWAN] — so they put pressure on their institutions and government to set up something. All of it is done by the community for the community,” Hyams said.

Key Protections for Students

• Though Title IX is recognized for boosting girls athletics, the law primarily prohibits sex discrimination in schools receiving federal funds. It aims to protect victims of sex-based harassment, including sexual assault. It also requires that all students have equal access to all academic subjects, including those required of STEM careers.

• Title VI protects students from racial discrimination in a wide array of activities, from admissions to athletics. It also protects against retaliation, with the idea that individuals can come forward and report when they experience or witness discrimination.

Title IX Update

Title IX guidance may signal broader civil rights attack, experts say.

By Sandra Guy, SWE Contributor

Title IX advocates are concerned that young women’s rights will be greatly damaged by the current administration’s decision to give colleges and universities a choice to use a tougher standard of evidence in sexual violence cases. And they fear the new interim Title IX guidance — what one critic called a “walk-back of students’ rights” — that will make it harder for sexual violence victims to gain justice — will lead to a similar weakening of Title VI, which prohibits racial discrimination in schools.

“Both Title IX and Title VI codified protections for students, so we are concerned about an across-the-board attack on students’ rights to be free of all types of discrimination in pursuing an education,” said Carly N. Mee, J.D., staff attorney for SurvJustice, a national victims’ rights group.

Indefinitely, Laura L. Dunn, J.D., SurvJustice’s executive director, told The New York Times Magazine, “An attack on Title IX could enable similar attacks on Title VI — the 1964 Civil Rights Act clause that forbids racial discrimination in schools, on which Title IX was modeled.” Since the case law around both is intertwined, she said, “If you’re rolling back Title IX, the next thing you roll back is Title VI.”

The fear is that the U.S. Department of Education will impose a restrictive view of Title IX that is contrary to the law. Before the Title IX or Title VI statutes could be repealed, Congress would be required to act.

For now, the Sept. 22 guidance from U.S. Secretary of Education Betsy DeVos withdrew the Obama administration’s “Dear Colleague” letter of April 4, 2011, and a follow-up statement of “Questions and Answers” issued on April 29, 2014. Obama’s guidance instructed colleges and universities to fight sexual harassment, including sexual violence, under Title IX, the federal law that prohibits sex discrimination. It threatened a loss of federal funds to institutions that failed to do so, required schools to resolve investigations within 60 days, and set a lower standard of proof for campus disciplinary hearings than that of criminal trials.

DeVos’ guidance lets colleges and universities set their own evidentiary standard for misconduct findings, allows them to use informal resolutions such as mediation, and sets up an appeals process for disciplinary sanctions. DeVos said the Education Department under her leadership was concerned that the Obama administration’s guideline had denied proper due process to the accused.

The proposed new guidelines would expand universities’ choices about the standard to use when judging sexual violence cases that fall under Title IX. The U.S. Education Department’s Office for Civil Rights in the Obama administration had said that schools should use a standard known as “preponderance of the evidence” — the standard that has always been used to adjudicate discrimination claims and extends to all stages and kinds of actions enforcing civil rights laws, according to a
white paper posted on the Feminist Law Professors blog. The blog highlights the work of feminist law professors nationwide and articles and events of common interest.

In the "clear and convincing evidence" standard, a party must prove not just that his version of events is "more likely than not" true. Instead, a party must prove that it is "substantially more likely than not" his or her claims are true, according to the Legal Information Institute.

Using a standard other than preponderance isn't appropriate for situations in which students' civil rights are on the line, says Anne Hedgepeth, interim vice president of public policy and government relations for the American Association of University Women (AAUW).

"It's a less fair standard of evidence in proceedings," Hedgepeth said. "This is a movement toward Title IX and Title VI statutes, "we would be

Women’s rights advocates are prepared to fight any rollback. If Congress tries to further weaken Title VI and Title IX statutes, "we would be prepared to push back because these are incredibly important protections that students desperately need to ensure they can safely pursue an education, free of discrimination," Mee said.

Farrell’s organization, Equal Rights Advocates, will set up a toll-free hotline for students, parents, and others concerned, and train a national network of attorneys who will provide free legal advice and step in if necessary to help victims of sexual assault. Both are expected to be ready in early 2018.

“Our goal is to work with student activists and colleges so students can feel safe enough to learn and have legal help ready," Farrell said. “We’re going to have representation of students on the ground.”

The effort will seek to help colleges and universities deal effectively with Title IX procedures — a worrisome issue because Title IX critics often say that schools do a poor job of it. "Schools that are ‘punting’ (on carrying out Title IX policies) are not meeting their legal obligation under Title IX and other laws — that is, to promptly investigate claims of sexual violence," Farrell said. "It’s a traumatic experience for the victims, and the schools should be supportive of them throughout the process."

The organization also intends to publicize and support colleges and universities doing it right.

"We want to uplift examples where it’s working, it’s fair, and it’s providing due process to both sides," she said.
Insights from SWE’s Community College Study

With greater attention and support, the community college pathway could be key to increasing diversity in engineering.

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

Many higher-education institutions have sought to make the transfer process from community college to a four-year university more seamless. Elements such as articulation agreements, transfer orientation sessions, and improved advising for transfer students have all been implemented to help ensure a smooth transition.

Given the separate initiatives aimed at increasing diversity in STEM and the data collected to measure progress, we might expect that data on STEM transfer students would be readily available. This is not the case. In fact, the limited research that is available hints at the unrealized potential of the community college pathway. Better support of this pathway may increase the number of diverse students receiving STEM degrees, and thereby increase diversity in the profession overall.

Hence, there is a need for more research on the community college route that focuses on disaggregated populations and STEM disciplines experiencing large gender and racial gaps. This data is necessary if we are to develop effective programs and services to meet the needs of STEM transfer students.

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There is a need for more research on the community college route that focuses on disaggregated populations and STEM disciplines experiencing large gender and racial gaps. This data is necessary if we are to develop effective programs and services to meet the needs of STEM transfer students.

Given that more than 80 percent of first-time community college students indicate that they intend to transfer and complete their baccalaureate degree, but only 33 percent successfully transfer, there is great potential to increase ECS diversity if we can better support this diverse pool of college students.

Community College Transfer in ECS

How successful are community college students who intend to transfer to complete an ECS degree? That is a question that many people ask, but relatively few can answer — and typically only at a local level. What we do know is that about 15 percent of two-year college students declare an ECS major, and that more than 65 percent of those students who do transfer in engineering successfully complete an engineering baccalaureate degree.

The National Science Foundation discovered that 47 percent of recent STEM graduates had done some coursework at a community college, and the reasons for doing so varied. Approximately 60 percent had attended community college to earn credits toward a bachelor’s degree, to better prepare themselves for a four-year program, or for financial reasons. Students with higher parental education levels were less likely to have taken community college courses, highlighting the important role that community colleges play in increasing access to a STEM education.

Community college students are often excluded from conversations surrounding broadening number of bachelor’s degrees, and degree attainment among people of color has increased.1 The ECS fields continue struggling to increase degree attainment among these underrepresented groups. Women earn only 20 percent of bachelor’s degrees in engineering, and this has stayed relatively flat since 1995. We are seeing decreases in women’s degree attainment in computer science, with only about 18 percent of bachelor’s degrees earned by women.2 Meanwhile, people of color now earn approximately 24 percent of bachelor’s degrees in computer science, but only 16 percent of bachelor’s degrees in engineering.3

Women of color are particularly underrepresented in ECS. In 2014, less than 4 percent of bachelor’s degrees in engineering and 5 percent of bachelor’s degrees in computer science were awarded to women of color.4 Despite efforts to improve diversity in these professions, women of color still make up less than 3 percent of all ECS professionals. A recent collaborative study by the Society of Women Engineers and the National Society of Black Engineers explored the experiences of women of color in the early stages of their engineering careers to gain insight into the issues affecting their retention in the profession. Highlights of that study are available in this issue.

To address the lack of diversity in ECS, there have been numerous initiatives aimed at increasing the number of women and people of color who choose to major in ECS, as well as programs and services to support them while in college. Diversity-serving organizations such as the Society of Women Engineers have established career development events, mentoring programs, scholarship opportunities, and community-building programs for college students, but much of this work has centered primarily on students attending four-year universities.

This attention on four-year institutions stands in contrast to data showing that almost 40 percent of undergraduates in the United States attend a public two-year college.5 Community colleges offer more flexible enrollment policies and schedules; hence, more than 60 percent of community college students are enrolled part time. Among recent STEM baccalaureate degree earners, almost half indicated that they had done some coursework at a community college, with women more likely than men to have attended a two-year college.

In addition, students of color are overrepresented in community colleges, with more than half enrolled in two-year programs.6 The importance of community colleges as a gateway to four-year universities has also increased due to recent societal changes, as college costs are on the rise, and student debt along with it. The College Board recently reported that tuition and fees have more than doubled at public four-year universities in the last 10 years.7 Student loan debt is now the second highest consumer debt, only behind mortgage debt, with average student loan debt for recent graduates at approximately $27,000.8 To mitigate some of the financial strain that comes with obtaining a college degree, many students are choosing to enroll in a community college and transfer to complete their bachelor’s degrees.

Given that more than 80 percent of first-time community college students indicate that they intend to transfer and complete their baccalaureate degree, but only 33 percent successfully transfer, there is great potential to increase ECS diversity if we can better support this diverse pool of college students.9
participation in ECS fields. While initiatives are underway to promote STEM diversity and transfer success, there are few programs available that are focused on the intersection of both issues. A number of universities are working with local community college feeders to smooth the transition for ECS students, but we struggle to understand the bigger picture. Data associated with the success of transfer students in ECS are difficult to obtain, presenting a challenge to organizations that seek to better support students on this pathway. As SWE and other diversity-serving organizations work to develop stronger supports for community college students interested in pursuing an ECS career, we ask: How do we know where to go if we do not know the baseline? How do we know what to do if we lack the data needed to design effective programs and services?

SWE’S COMMUNITY COLLEGE STUDY

To examine these questions, SWE initiated a research study to understand the issues that women and other underrepresented students in ECS face on the community college path, toward an ECS bachelor’s degree. The first phase of this two-phase study was completed in late 2017 and involved an exploratory study of existing education data in Texas, including the rates of degree completion of approximately 436,000 transfer students over a 10-year period.

Methodology

SWE obtained permission to access student-level data from the Texas Education Research Center, housed at The University of Texas at Austin. Utilizing longitudinal datasets beginning with the 2002/03 school year, SWE analyzed enrollment data, major selection, and student demographics from 60 two-year colleges and 25 four-year universities in Texas to better understand the transfer success of underrepresented students in ECS, particularly women and women of color. Mindful of student confidentiality requirements, data were disaggregated by gender and race/ethnicity when sufficient numbers of students were available.

Data were analyzed by first-time-in-college (FTIC) cohorts. Degree-seeking students are included in an FTIC cohort only after leaving high school, so students enrolled in dual credit courses are not included in a cohort until after high school graduation. Degree completion is reported by FTIC cohort. Rather than considering the amount of time taken to complete a bachelor’s degree, this study considers completion of students who earned an ECS baccalaureate degree by fall 2015, the last semester of data available from the Texas Education Research Center.

Due to extremely low counts among women of color, the scope of the first phase of this study was expanded to include the success of women and people of color who chose to major in ECS, regardless of the type of institution they first enrolled in. However, the primary goal of the study was to gain a better understanding of women’s transfer success in ECS; hence, data were disaggregated where possible, and collapsed across larger student groups when necessary to avoid confidentiality issues.

Results

One of the first observations made in this study of Texas data was that more women than men are enrolled in college, but far fewer women declare a major in ECS than do men. This is unsurprising, as national data indicate that only about 8 percent of female first-year students intend to major in engineering, math, statistics, or computer science compared with 37 percent of male counterparts. However, what is surprising is that only about 4 percent of women in Texas declared an ECS major among students who entered a two-year or four-year college as first-time, first-year students at any point between 2002/03 and 2011/12. In any given year of this study, between 22,000 and 27,000 students declared an ECS major in Texas, and during this time, approximately five times as many men than women chose to major in ECS. As a result, about one in five students in ECS majors in Texas are women, and this ratio has remained relatively constant over time (Figure 1).

On a brighter note, women are increasingly staying in ECS majors and graduating with ECS baccalaureate degrees. Though only one out of three students, regardless of gender, were still enrolled in an ECS program or had graduated with an ECS degree by fall 2015, women’s persistence rates have increased significantly from the 2002/03 FTIC cohort to the 2010/11 FTIC cohort. Male persistence rates have also increased over this same period, but female persistence rates have surpassed male persistence rates over time, reaching 30 per-
cent for the 2010/11 FTIC cohort compared with 28 percent for men from the same cohort. Keeping in mind that students of later cohorts could still leave ECS if they have not yet graduated, the increase in persistence among women is still clearly outpacing that of men, as shown in Figure 2.

Another positive finding was that fewer women are leaving ECS majors to obtain non-ECS bachelor’s degrees. Retaining women in ECS is critical to improving the gender diversity in these fields, and the trends highlighted in Figure 3 indicate that the efforts being made to retain women are having a positive impact on their choice to stay in ECS programs.

When looking at the success of women of color, persistence and completion rates of ECS students were lowest among African-American and Hispanic women (Figure 4). While there were more women still enrolled in ECS and working toward their degrees in the 2010/11 FTIC cohort than in the 2002/03 FTIC cohort, African-American women have experienced a decrease in ECS baccalaureate completion rates over this time period. These findings are in line with national trends, where we have seen a drop in the percentage of ECS degrees earned by African-American women over time. However, persistence among African-American women has increased sixfold, which may indicate that more African-American women are choosing to stay in ECS and are taking longer to graduate. Women generally had higher ECS persistence and degree completion rates compared to men of the same race/ethnicity from the 2010/11 FTIC cohort, a change from earlier years when male persistence and degree completion rates exceeded those of female students.

Impacting persistence in ECS is the number of students who change majors, switching out of ECS into a non-ECS degree program. In Texas, a high percentage of students are declaring an ECS major and later switching to a non-ECS major, across both genders and at both two-year colleges and four-year universities. In this study, 12 percent of community colleges and 24 percent of four-year universities had more than half of their female ECS students switch out of ECS while pursuing a degree, while only one four-year institution in the state saw such high switch rates among men.

Considering the low number of women choosing to major in ECS, retaining them in the major, even at rates equal to those of men, would significantly address the gender gap in these fields. In any given year, Texas sees tens of thousands of students transferring from two-year to four-year higher education institutions to complete their degrees. More women than men are transferring, but less than 2 percent of female transfer students chose an ECS major compared with 11 percent of male transfer students. Over the 10 years of data included in this study, more than 240,000 women transferred from a two-year to a four-year college. Fewer than 4,000 declared a major in engineering or computer science.

Of great importance is the fact that when community college students majoring in ECS transfer, they are successful at completing their degrees. Completion rates among ECS transfer students exceeded 60 percent for men and 50 percent for women for the 2005/06 FTIC cohort. Granted, these students had 10 years to complete their degrees before fall 2015, the last semester of data available for this study, but this highlights the tenacity of many of the students who begin their journey at a two-year college.

Table 1 lists the number of male and female community college transfer students who earned an ECS baccalaureate degree from the FTIC cohorts included in this study. Over time, the percentage of female ECS transfer graduates is increasing, even though male ECS transfer graduates outnumber females in each cohort. This is due to both the fact that female persistence and completion rates are increasing and male persistence and completion rates are not keeping pace.

Due to the low counts of women of color who

**FIGURE 3**

ECS Majors Who Earned a Baccalaureate Degree by Fall 2015, by Gender, FTIC Cohort, and ECS vs. Non-ECS Degree

**FIGURE 4**

Persistence and Completion Rates of Female ECS Majors, 2002/03 and 2010/11 FTIC Cohorts, by Race/Ethnicity
transferred in ECS, analysis of disaggregated data was limited. Of the female transfer students who earned an ECS bachelor’s degree, 45 percent were women of color. Among male transfer ECS degree earners, 30 percent were men of color.

Of the more than 25,000 students in Texas who transferred from a two-year to four-year college from the 2010/11 FTIC cohort, fewer than 500 were women who chose an ECS major. This is undoubtedly extremely low, and the percentage of female transfers choosing to major in ECS has remained relatively unchanged over the 10 FTIC cohorts in this study. Though it is disheartening to realize that fewer than 1,000 female transfer students in Texas received ECS bachelor’s degrees over this 10-year period, the increases we see in persistence rates and completion rates among female students, and female transfer students in particular, are strong indicators of the impact to diversity we could see in engineering and computer science if we can encourage more women to consider an ECS major.

### TABLE 1

<table>
<thead>
<tr>
<th>FTIC COHORT</th>
<th>FEMALE</th>
<th>MALE</th>
<th>% FEMALE OF TOTAL ECS TRANSFER GRADUATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002/03</td>
<td>253</td>
<td>1,733</td>
<td>12.7%</td>
</tr>
<tr>
<td>2003/04</td>
<td>191</td>
<td>1,466</td>
<td>11.5%</td>
</tr>
<tr>
<td>2004/05</td>
<td>203</td>
<td>1,388</td>
<td>12.8%</td>
</tr>
<tr>
<td>2005/06</td>
<td>214</td>
<td>1,382</td>
<td>13.4%</td>
</tr>
<tr>
<td>2006/07</td>
<td>187</td>
<td>1,338</td>
<td>12.3%</td>
</tr>
<tr>
<td>2007/08</td>
<td>195</td>
<td>1,241</td>
<td>13.6%</td>
</tr>
<tr>
<td>2008/09</td>
<td>161</td>
<td>992</td>
<td>14.0%</td>
</tr>
<tr>
<td>2009/10</td>
<td>140</td>
<td>731</td>
<td>16.1%</td>
</tr>
<tr>
<td>2010/11</td>
<td>85</td>
<td>391</td>
<td>17.9%</td>
</tr>
</tbody>
</table>

Number of Transfer Students Who Earned an ECS Baccalaureate Degree by 2015, by Gender and FTIC Cohort

**Recommendations**

There is great potential to address the need for more ECS graduates while improving both the gender and racial diversity of the ECS professions if we can retain more community college students in ECS and support them through transfer. Though the outcomes from our research indicate that low numbers of women and people of color in Texas are transferring in ECS, the relatively high rates of successful ECS bachelor’s degree completion among ECS transfer students indicate that encouraging those students who choose an ECS major to remain in the major could have a huge impact on increasing diversity in these professions. We must address the recruitment and retention of community college students in ECS majors and support them through the transfer process. To help us develop effective programs and services for these students, a few key actions can be taken:

- Encourage institutions and government entities to report disaggregated data that allow supporting organizations to study specific subgroups in STEM who may require more attention. Underrepresented student groups in ECS are difficult to parse out when reported under a general STEM category.
- Identify what community college students need to be successful in ECS. We need to understand the specific challenges and obstacles they face so we can develop programs and services that meet their needs.
- Develop goals and metrics to measure ECS transfer student success. If diversity in ECS is important, we must set goals, allocate resources to meet those goals, and measure progress toward those goals.

As this study shows, gender and racial gaps among transfer students in ECS are significant, and more research is needed to determine what supports are necessary to increase the number of students staying in ECS majors at a community college and transferring to a four-year university, particularly among women and underrepresented minorities. Increasing diversity in ECS fields will require support from more than just the higher education community. Organizations such as SWE can help, as can government entities, industry, and other nonprofits interested in diversifying engineering and technical professions, by providing more support to students interested in transferring—before, during, and after transfer.

**WHERE DO WE GO FROM HERE?**

This study was launched in support of SWE’s strategic efforts to develop women engineers at all stages of their personal and professional lives. Engaging community college women pursuing ECS degrees requires a better understanding of the challenges they face so effective programs and services can be developed to meet their needs. SWE’s relationships with other diversity-serving organizations allow for sharing of this research to inform their efforts as well.

SWE is developing the second phase of this two-phase project, which will entail a qualitative study of women on the community college pathway and a pilot program to introduce community college women to the collegiate, professional, and corporate networks that SWE offers. An update on the progress of this research and the efforts SWE has made in developing programs and services for this target population will be shared at the SWE conference in October 2018.

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**To download a copy of the research report, visit [https://research.swe.org](https://research.swe.org). This research was made possible by the generous support of the Society of Women Engineers Corporate Partnership Council.**

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**Endnotes:**

2. For the purposes of this article, reference to people of color includes individuals of Hispanic, African-American, or American Indian/Alaska Native descent.
13. Texas Higher Education Coordinating Board CBMoor reports, 2002/03 to 2015/16. Data regarding major declaration was available through fall 2015. Includes all public two-year and four-year enrollees.
14. Texas Higher Education Coordinating Board CBMoor and CBMoor9 reports, 2002/03 to 2015/16. Includes all public two-year and four-year enrollees who declared an ECS major between the 2002/03 school year and spring of the 2014/15 school year.

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Understanding the Early Career Experiences of Women of Color

To shed light on the early career challenges, strategies, and supports for women of color, SWE and NSBE conducted a joint study.

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

For decades, organizations such as the Society of Women Engineers and the National Society of Black Engineers have brought together students and professionals from underrepresented groups, welcoming them into a supportive engineering community that facilitates relationship development and networking among engineers who share a common characteristic. But even within these professional engineering associations, engineers are not all alike. Individuals have intersecting identities; for example, the race and gender with which we most identify can be at the root of very different experiences; for example, the race and gender with which women of color face when they experience both sexism and racism in their careers.

Today, less than 6 percent of engineering bachelor’s degrees are awarded to African-American, Hispanic, Native American, and Asian women combined. Women of color represent less than 5 percent of the engineering workforce. Though professional engineering associations such as SWE and NSBE provide services and support to women of color, it is unclear the degree to which women find these resources helpful.

SWE and NSBE conducted a joint study to gain a better understanding of the experiences of women of color in the early stages of their engineering careers. Given the high rate of attrition among women in engineering, coupled with the low representation of women of color in engineering, addressing the retention of women of color in the engineering workforce will help increase the diversity in the profession. Understanding the specific challenges these women face, the strategies they applied to overcome challenges, and the types of supports they find most impactful can inform the development of supportive programs and services from diversity-serving organizations.

METHODOLOGY

The findings from this study are based on interviews conducted with 32 women of color who graduated after May 2011 and had been employed in the engineering workforce for at least one year following graduation. Table 1 lists selected participant demographics, and Table 2 provides a breakdown of the engineering disciplines represented in the study sample. Researchers analyzed interview transcripts, categorizing the challenges, strategies, and supports shared by the women interviewed, and identified emerging themes.

RESULTS

The findings from this study were categorized as challenges, success strategies, and external supports. The following is a summary of the challenges and supports identified by study participants.

CHALLENGES

We wanted to understand the specific challenges women of color face when they begin their engineering careers. Prior research suggests that women of color experience a variety of negative factors in the workplace, including stereotype threat, lack of role models, and feelings of isolation. Our findings indicate that female engineers of color in the early stages of their careers are experiencing such issues and, in some cases, are seeing the impacts on their career advancement.

The challenges expressed by women in this study included:

• Lack of role models for minority female engineers
• Disillusionment regarding level of impact they would have as engineers
• Gender and racial biases and stereotypes experienced in the workplace
• Dissatisfaction with salary and benefits (only 35 percent had negotiated salary when they were first hired)

TABLE 1

<table>
<thead>
<tr>
<th>RACE</th>
<th>COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian/Pacific Islander</td>
<td>2</td>
</tr>
<tr>
<td>Black or African-American</td>
<td>18</td>
</tr>
<tr>
<td>Hispanic or Latina</td>
<td>8</td>
</tr>
<tr>
<td>Native American/Alaska Native</td>
<td>2</td>
</tr>
<tr>
<td>Mixed Race</td>
<td>1</td>
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</table>

<table>
<thead>
<tr>
<th>AGE (YEARS)</th>
<th>COUNT</th>
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<tbody>
<tr>
<td>&lt; 25</td>
<td>4</td>
</tr>
<tr>
<td>25-29</td>
<td>22</td>
</tr>
<tr>
<td>30+</td>
<td>4</td>
</tr>
<tr>
<td>No Response</td>
<td>1</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>MARITAL STATUS</th>
<th>COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
<td>7</td>
</tr>
<tr>
<td>Single</td>
<td>24</td>
</tr>
</tbody>
</table>

Participant Demographics

“I THINK THAT THERE’S A LOT OF MENTALITY — THERE HASN’T BEEN A LOT OF WOMEN IN MY PARTICULAR JOB FOR A COUPLE YEARS. THERE ARE JOKING COMMENTS. I THINK PEOPLE USUALLY APOLOGIZE ... I GUESS I DIDN’T EXPECT SOME OF THOSE MENTALITY JOKES TO STILL BE THERE.”

– Latina engineer

“I KNOW I’M 1 PERCENT OF PEOPLE THAT ... LOOK LIKE ME. I’VE KNOWN THAT THROUGH MOST OF COLLEGE. I’VE ALWAYS COUNTED. SO SOMETIMES WHEN I DO FEEL INSECURE, IT DOES BRING UP THAT YOU’RE ALSO THE ONLY PERSON OF COLOR OR FEMALE IN THERE.”

– African-American engineer

Table 2

<table>
<thead>
<tr>
<th>COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace Engineering</td>
</tr>
<tr>
<td>Chemical Engineering</td>
</tr>
<tr>
<td>Civil Engineering</td>
</tr>
<tr>
<td>Computer Science</td>
</tr>
<tr>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Industrial Engineering</td>
</tr>
<tr>
<td>Manufacturing Engineering</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
</tr>
<tr>
<td>Software Engineering</td>
</tr>
<tr>
<td>Systems Engineering</td>
</tr>
</tbody>
</table>
UNFAIR PERFORMANCE EVALUATIONS AND LACK OF HONEST FEEDBACK (ONLY 58 PERCENT INDICATED FEELING THAT THEY RECEIVED A FAIR PERFORMANCE EVALUATION)

DIFFICULTY OBTAINING PROFESSIONAL DEVELOPMENT THROUGH EMPLOYERS

EXTERNAL SUPPORTS
Women were asked about the external supports they relied upon to assist them during their job searches and into their first years of their engineering careers. While a few women had family members who were engineers or worked in technical fields who could offer job search advice, most had to turn elsewhere to find support in addressing the challenges mentioned earlier, including mentors, colleagues, and professional engineering associations.

Among those interviewed, 94 percent had been members of professional engineering associations during college. Some stated that they felt a connection to these organizations primarily because they could identify with other members of similar race or gender in engineering. All but two women were current members of at least one professional engineering association. Though some expressed a desire to better utilize the programs and services offered by these organizations, others stated that their professional associations helped them feel less isolated as they moved into the workforce.

RECOMMENDATIONS
The purpose of this study was to determine ways in which professional engineering associations such as SWE and NSBE can better support women of color in the early stages of their careers. Based on the findings, researchers offered the following recommendations:

- Increase diversity in age and background within the organization, particularly among leadership
- Determine ways to maintain relevance and better support women following a job relocation
- Better accommodate women’s busy schedules and dispersed locations to make it easier for women to remain active members
- Diversify events and workshop topics so women see the benefit of continuing their membership
- Help women of color find the mentors they seek as they change employers, positions, and locations

To view the full report, please visit [https://research.swe.org/](https://research.swe.org/).

Endnotes:
1. The challenges women of color in STEM face were first introduced in the American Association for the Advancement of Science (AAAS) publication The Double Bind: The Problem of Being a Minority Woman in Science (Malcom, Hall, and Brown, 1976).
3. For the purposes of the research study discussed in this article, women of color include women who identify as primarily nonwhite.

“’I’VE ACTUALLY BEEN PRETTY LUCKY TO HAVE GOOD MENTORS THROUGHOUT ALMOST MY WHOLE CAREER.’

— Native American engineer
Then and Now: Women Engineers’ Perspectives on Changes and Challenges in the Field Since the 1970s

Understanding the career trajectories and experiences of women who came of age during the 1970s may help institutions develop better means of supporting female engineers today.

By Laura Ettinger, Ph.D., Nicole Conroy, Ph.D., and William Barr II

The number of women in engineering continues to be relatively small, and even when women enter the field, they often do not stay. Researchers have explored why these problems persist and have offered many suggestions for changing the landscape, yet problems with recruitment and retention remain, and solutions seem elusive. Although women engineers, particularly those who have been in the profession a long time, are in excellent positions to see the problems and to suggest ways to create a more welcoming and inclusive profession, they have rarely been engaged in seeking solutions. In our project, funded by the National Science Foundation, we address this limitation by inviting women engineers to share their stories.

Our research assesses a pivotal generation of pioneering American women engineers who graduated from college in the 1970s. In that decade, young women, encouraged in part by the number of women in engineering as a result of a love and/or aptitude for math and science or because of encouragement by others in “a time of space and science.” They continued to enjoy the opportunity to solve challenging problems, to do meaningful and varied work, to work with smart colleagues, and to help others in a prestigious field where they could be financially successful.

CHALLENGES THEN AND NOW

The open-ended, multipart survey question: ‘In your experience, what is one of the greatest challenges faced by young women engineers? By experienced women engineers? To what extent do you believe the challenges have changed over time?’ yielded especially rich answers.

Some respondents distinguished between the challenges facing young vs. experienced women engineers, while others did not. Regardless, the challenges facing women engineers mentioned most frequently can be divided into three themes: 1) not getting respect, 2) not fitting in, and 3) work/family balance.

CHALLENGE #1: NOT GETTING RESPECT

The most frequently mentioned of the challenges (32 percent of respondents who answered this question) was not getting respect from peers and supervisors. This was also expressed as not being taken seriously, not being heard, having to prove oneself repeatedly, and people not believing that women can be engineers.

One survey respondent suggested that women engineers do eventually gain respect, but they have to do extra work to get it: “In mentoring young female engineers, I have found that they face most of the same problems that all women faced in the workforce when I started working and when I retired. Some male colleagues did not/do not respect the opinion or work of a female engineer, regardless of her experience or education. Until they experience the female engineer being competent and respected by others in the organization, they are disrespectful and do not listen or respond appropriately.”

Some explained that women “have to work twice as hard” as men to prove themselves. Or, as another woman put it, “women engineers will be fully part of the field when mediocre female engineers are accepted as easily as mediocre male engineers.” She wasn’t sure whether this has occurred, as she left the workforce following the birth of her children and a lack of quality child care.

CHALLENGE #2: NOT FITTING IN

Twenty-two percent of the respondents who answered this question said that one of the greatest challenges

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race**</td>
<td></td>
</tr>
<tr>
<td>Caucasian/White</td>
<td>93</td>
</tr>
<tr>
<td>Asian/Asian-American</td>
<td>2</td>
</tr>
<tr>
<td>Latino(a)/Hispanic</td>
<td>2</td>
</tr>
<tr>
<td>African-American/Black</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
</tr>
<tr>
<td>Where did you grow up?</td>
<td></td>
</tr>
<tr>
<td>In the U.S.</td>
<td>91</td>
</tr>
<tr>
<td>Outside the U.S.</td>
<td>9</td>
</tr>
<tr>
<td>Undergraduate degree</td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>82</td>
</tr>
<tr>
<td>Math/Science/Computer science</td>
<td>13</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
</tr>
<tr>
<td>Primary employment industry</td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>22</td>
</tr>
<tr>
<td>Education</td>
<td>20</td>
</tr>
<tr>
<td>Consulting</td>
<td>8</td>
</tr>
<tr>
<td>Electric, gas, sanitary services</td>
<td>5</td>
</tr>
<tr>
<td>Transportation</td>
<td>4</td>
</tr>
<tr>
<td>Construction</td>
<td>3</td>
</tr>
<tr>
<td>Public administration</td>
<td>3</td>
</tr>
<tr>
<td>Health care</td>
<td>2</td>
</tr>
<tr>
<td>Technical sales</td>
<td>2</td>
</tr>
<tr>
<td>Communications</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>29</td>
</tr>
</tbody>
</table>

Sample demographic information (N = 244)

**Participants could select “all that apply”; thus the total exceeds 100 percent.
experienced by women engineers was and remains not fitting in. They articulated this as feeling or being left out; isolation; being told they didn’t belong; being an oddity; and not having access to “good old boys networks.”

A number of women said this was especially difficult when they were younger because women engineers were so unusual then.

“When I was a young engineer my biggest challenge was convincing others on the job that I was more than a temporary freak show.”

Many women explained that the challenges of not fitting in have continued.

“The biggest challenge is being reminded that women will never be considered or accepted as true engineers. We are ‘women engineers.’ People don’t refer to a man as a ‘man engineer,’ he’s an engineer. We are engineers. We are ‘women engineers.’ People don’t refer to a man’s control. The biggest challenge is being reminded that women will never be considered or accepted as true engineers. We are ‘women engineers.’ People don’t refer to a man as a ‘man engineer,’ he’s an engineer. We are engineers. We are ‘women engineers.’ People don’t refer to a man’s control.

WHAT APPEARS TO BE PERSONAL CHOICE (I.E., THE DECISION NOT TO SEEK OUT CERTAIN OPPORTUNITIES) IS OFTEN CONSTRAINED BY EXTERNAL FACTORS BEYOND A WOMAN’S CONTROL.

In the words of another respondent, this kind of institutional bias “can really hurt young women because it can take them years to recognize it, by which time they may have lost a lot of ground.”

However, not all of the women reported that “progress is slow.” Some women maintained that prejudices due to gender no longer exist, or never existed. Others said that things have gotten dramatically better for women engineers or that they have an advantage now.

“Today, young women engineers are more accepted mostly because there are just more of them. It’s easier to get their foot in the door. Younger male engineers are also use[d] to working with women because they went to school with them. Therefore they don’t think much of it, or why use[d] to be such a big deal.”

“When I first started, it was like you weren’t even in the room. Now, it is not a ‘thing’ that the young men or women even notice when working. [Many young women are in management — not upper, yet — and have husbands at home.] Nice to see attitudes and behaviors changing.”

A few said that things are harder for women today. Several noted that the persistence of gender bias varies by industry.

ADVICE FOR YOUNG WOMEN

In response to “What advice would you give to a young woman who is thinking about pursuing a career in engineering?” 16 percent of respondents stated enthusiastically that young female engineers should either “Do it!” or “Go for it!” In fact, only two women said they would discourage women from pursuing engineering careers.

For some of the pioneers, becoming an engineer extended beyond the satisfaction of the profession and for others, skills translated into employment in other fields altogether. As one woman noted, an engineering degree “gives you flexibility to work in a variety of capacities and in a variety of industries.” While supportive, some pioneers argued that young women need more than a degree to prepare for the challenges they may face: “being yourself” and having “thick skin” were suggested as important coping strategies.

“Be persistent about it and never give up. Having a stubborn streak also helps. This is still true: a woman has to be twice as good as a man to be considered half as good. However, this is not difficult.”

Others stressed the importance of finding a supportive network.

“Understand the story of women engineers, the battles they faced, the barriers they broke and how the tactics they used to move forward can help you as you progress. Use the ‘Old Girls Network’ — it does exist. SWE is a good place for that, but so are other technical societies in your field. There are women there who might have encountered a similar situation that can help.”

Some likewise advised identifying both male and female mentors early on.

“Find a good mentor, maybe multiple mentors both male and female and in engineering and not in engineering.”

Others suggested that young women engineers should not focus on “looking for discrimination. It may exist, but it’s not productive to analyze every interaction for signs of discrimination.”

Despite acknowledging the difficulties that women are likely to face in engineering, many of the pioneers implored young women to “follow your passion” of problem-solving to enact change.

“I encourage young women to do it if they care about solving the world’s problems. An engineering education provides a strong basis for studying a situation or figuring out how to make it better, so even if they ultimately decide to pursue a different field, they...”
will have a fabulous foundation for decision making for the rest of their lives.”

Yet, again, others were quick to remind future female engineers of the gender-related troubles they may face.

“I would encourage them to follow their passions but also be honest that mechanical, electrical, and aerospace engineering are still a ‘man’s world’ and they need to be prepared for that.”

In sum, while some pioneers debated the impact of gender-based discrimination on young women’s futures, others advised that women engineers can succeed by following their passions, securing marketable skills, and through mentorship and networking.

**DISCUSSION AND COMMON THEMES**

Survey respondents overwhelmingly recommended that young women pursue engineering degrees or careers. However, most of the pioneers also reported that they faced a number of challenges, some of which they still see in engineering. While many suggested that things had improved for women in engineering since the 1970s, others emphasized that “progress is slow.”

The three most frequently cited challenges — not getting respect, not fitting in, and work/family balance — are connected. When you don’t fit in, whether it’s because you actually don’t fit in, you’ve told you don’t fit in, or you feel you don’t fit in, you have to prove yourself repeatedly. This is what Joan C. Williams, J.D., et al. call the “prove-it-again bias,” referring to the many studies that show that “women and people of color often need to be more competent than white men in order to be seen as equally competent.”

The challenges of not getting respect and not fitting in are connected to the third challenge: work/family balance. Work/life balance will inevitably be a challenge for women so long as institutions devalue their contributions.

**RECOMMENDATIONS**

Our preliminary findings suggest that although the engineering landscape has changed for women over time, it is far from equitable. To work toward the goal of greater gender inclusivity in engineering, we offer three primary recommendations:

**Mentoring.** Pioneers cited the importance of finding a supportive network and multiple male and female mentors. The Society of Women Engineers and other engineering organizations have long advocated and promoted mentorship. We recommend that engineering organizations create mentoring programs, based on social science research and with appropriate training for mentors and mentees, which tap specifically into the experiences and perspectives of late-career and retired women engineers. As evidenced by their rich survey responses, pioneering women engineers have valuable experiences and wisdom to share, and a desire to do so. Today’s young women in engineering are, in a sense, still pioneers, so learning from the women who came before them can demonstrate that the young women’s experiences are neither irrelevant nor isolated incidents. We also recommend that mentoring programs acknowledge that women need different types of mentoring at different stages of their careers and lives.

**Interdisciplinary approach.** Engineering has been trying for decades to increase the number of women in the profession. We recommend taking an interdisciplinary approach to this problem, as well as to address the cultural challenges facing not just engineering, but many other professions, as evidenced, for example, by the recent #MeToo and #TimesUp campaigns. Social scientists can provide an interdisciplinary framework to help dismantle the complex, structural challenges women have faced and continue to face in engineering, and that may otherwise feel insurmountable.

**Empathy and action.** The pioneers have generously told us their powerful stories. Their stories have the potential to create empathy and provoke necessary action.

We recommend that these stories be used to create “empathic unsettlement” — what we’re calling “empathy and action” — a concept from Dominick LaCapra, Ph.D., that suggests we should try to feel another’s struggle (empathy) while realizing that we cannot fully understand what someone else experiences. Therefore, we must be willing to be unsettled by both empathizing and knowing that fully doing so is not possible. For the profession to become more inclusive and to realize its full potential, senior management in particular, most (though not all) of whom are male, must be willing to listen for and examine their own unconscious biases. In leading these discussions by example, both men and women in positions of influence will be more willing and able to create an environment in which discussions of unconscious biases focus on questioning stagnant institutional practices.

**CONCLUSION**

The pioneering women engineers who responded to our survey discussed both the satisfaction and challenges they experienced in their careers, as well as the challenges they faced and those that continue in the profession. Given the changes in laws (in hiring, sexual harassment, and family leave, for example) and culture since the 1970s, it seems like women engineers should be celebrating their collective progress, and many are. The hard-to-identify challenges rooted in gender bias, however, resulted in many of the women saying: “things have changed, but…”

Endnotes:
1. National Science Foundation Award #1734500: https://www.nsf.gov/awardsearch/showAward?AWD_ID=1734500&HistoricalAwards=false

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William Barr II is a research assistant at Clarkson University, working with Laura Ettinger, Ph.D., on her project “Breaking Ground: American Women Engineers from the Baby Boom Generation.” He graduated summa cum laude from The State University of New York at Potsdam in May 2017 with majors in history, literature, and sociology, and a minor in women’s and gender studies. Barr plans to pursue a doctorate in sociology in the fall of 2019.
Once again, SWE has taken on the enormous task of summarizing a year’s worth of broad-ranging, interesting, and timely research about women in engineering. Our annual literature review serves as the starting point of this State of Women in Engineering issue of SWE Magazine, and its release is something we look forward to.

Now in its 16th year, the literature review offers more than basic information and a bibliography. The literature review provides analysis and insight into the research questions social scientists pose regarding the experiences of women in engineering, as well as experiences of female students in university classrooms and in K-12 education. It also provides an opportunity to see how far we have come. The list of women deans, for example, is much more extensive than just a decade ago. But at times, the literature review serves as a stark reminder that there is still a tremendous amount of work to be done, and areas that require new research questions and exploration.

This year, we also present new studies that are either funded by SWE or have utilized the resources of the Society — its members, its corporate sponsors, and its reach to women around the world who are struggling with the same issues around inclusion, access to resources, and work/life integration.

Because of research, we have come to better understand that, while all women engineers share an engineering identity and the experience of being female in a male-dominant profession, other dimensions of personal identity come into play. These shape how one experiences and understands issues that take place in school or work. Women of color, for example, also experience being a minority in terms of race. Further, women who do not identify as heterosexual find themselves in work-places where heterosexuality is presumed, hence the notion of intersectionality, or the intersection of a person’s multiple identities. This concept is discussed in the literature review and addressed particularly in the joint study SWE conducted with the National Society of Black Engineers (NSBE), and reported on here in “Understanding the Early Career Experiences of Women of Color.”

Having collaborated on many issues over the years, SWE and NSBE undertook this study of minority women early in their careers, seeking to answer a number of questions. We wanted to understand whether this group of women face the same challenges as their majority counterparts. And we wanted to know how professional engineering organizations, especially the diversity societies, can provide the most beneficial programs and support.

The joint study with NSBE dovetails with another study SWE recently concluded — that of community college students’ persistence into four-year engineering curricula. A higher percentage of minority students start their degrees at community colleges, making this pathway toward an engineering degree a potential means of increasing diversity in the engineering workforce. Results and conclusions from the study indicate that this pathway offers potential to graduate more diverse engineers, but many more supports for these students need to be in place.

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

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The State of Women in Engineering, 2018 edition of *SWE Magazine* is made possible through the support of:

The *SWE Magazine* State of Women in Engineering edition provides an overview of recent research and covers the most important trends affecting the advancement of women in engineering. This edition is supported in part by Cummins Inc. and the National Science Foundation (award ID: 1548200). Through this project, SWE is able to both advance its mission and further empower the persistence of women in engineering and technology at all stages of their careers.