Christianne Corbett and Catherine Hill, selection from Solving the Equation: The Variables for Women's Success in Engineering and Computing (AAUW, 2015).

Study after study finds that women have ability, good grades, and high test scores in STEM subjects, and yet women are turning away, or being pushed away, from engineering and computing fields. A theme that overarches much of the research on this topic is that women often feel as if they don't fit or belong in these fields. Research into this perceived lack of fit provides a complex picture of social and environmental factors influencing and interacting with individual motivations and values that are, in turn, also influenced by the wider culture. This chapter describes the latest research on structural and cultural factors in engineering and computing that may contribute to women's underrepresentation in these fields.

STRUCTURAL AND CULTURAL BARRIERS

As past decades have shown, simply trying to recruit girls and women into existing engineering and computing programs and workplaces has had limited success. Catalyst (2014) found that women in business roles at technical companies, like women in technical roles at these companies, tend to leave at higher rates than their male peers do (53 percent of women compared with 31 percent of men after their first post-MBA job). This finding suggests that the overall workplace culture and environment in technical industries may not be working for women, whether or not they are in technical roles. In both college and workplace environments, institutional structures and practices and more general cultural factors may contribute to the underrepresentation of women in engineering and computing fields.

NARROW FOCUS

One significant impediment, according to some scholars, is an emphasis on logical thinking at the expense of critical thinking in engineering culture (Claris & Riley, 2012). Scholars have pointed to a culture in engineering that discourages thinking beyond the technical parameters of a given problem (Cech, 2014). Engineering students, for example, are rarely asked to reflect on what they do, why they do it, and what the implications might be (Baillie & Levine, 2013). Specifically, the "culture of disengagement" in many college engineering programs does a poor job of training future engineers in their ethical and social responsibilities and cultivates an understanding of nontechnical concerns, such as the public welfare, as irrelevant to "real" engineering work (Cech, 2014). These elements of engineering culture are not confined to the college environment but persist once engineers enter the workforce, and although they are likely to discourage many women and men from pursuing engineering, they are perhaps especially discouraging for women because women are more likely than men to express a preference for work with a clear social purpose (Konrad et al., 2000).

Engineering and computing programs typically include high course load and workload requirements. Engineering curricula, in particular, are often rigid, making it difficult for students to transfer into engineering if they do not start out in it. One study attests to this difficulty, finding that 90 percent of those studying engineering in their eighth semester in college had identified engineering as their major when they began college (Ohland et al., 2008). Among students with strong mathematical aptitude (including most engineering and computing students), women are more likely than men to also have strong verbal aptitude (Wang et al., 2013). The constrained curriculum in engineering and computing may make it difficult for students to take elective courses in other fields or take advantage of other extracurricular opportunities that can be valuable contributors to the college experience, especially for students with broad interests and aptitudes. For example, one study found that students majoring in engineering and computing were the least likely of all students to take foreign language courses or participate in study abroad programs (Lichtenstein et al., 2010).

ISOLATION

Women in engineering and computing fields often report isolation, a lack of voice, and a lack of support (Ayre et al., 2013; Fouad et al., 2012; Hewlett, Buck Luce et al., 2008; Hewlett, Sherbin et al., 2014; Servon & Visser, 2011). A study of women and men working in technology at 21 high-tech companies found that women were less likely than men to indicate that their supervisors were receptive to suggestions, less likely to say that their supervisors were available when they needed them, and less likely to agree that "it is safe to speak up most of the time" (Catalyst, 2008). In one study of women in private-sector technical jobs, a third said that they felt extremely isolated at work. In the same study, four of 10 female engineers and computing professionals reported lacking role models, while about half reported lacking mentors (Hewlett, Buck Luce et al., 2008).

STEREOTYPICAL SURROUNDINGS

The physical environment in engineering or computing classrooms and workplaces can make a difference in how comfortable women find the environment. In one study, female students who entered a room containing stereotypical "geek" objects were less likely to identify themselves with computing or feel they belonged with a company or on a team (even an all-female team) than did women who entered a room containing gender-neutral objects (Cheryan et al., 2009).

SOCIAL NETWORKS LESS HELPFUL FOR WOMEN

Social networks appear to be less beneficial for women than for men, perhaps especially in computing. An analysis of social networks among undergraduate management information systems (MIS) students as they searched for jobs found that although social networks improved individuals' job prospects, women's social networks did not provide the job opportunities that men's networks did (Koput & Gutek, 2010). For example, one male student who had a C average, many male contacts, and very few female contacts participated in 16 job interviews, received five job offers, and started his career with a high salary. In contrast, women in the study, who also had many male contacts, generally did not get many job interviews or end up with high salaries, even if they had high grades. According to Koput and Gutek (2010, p. 71), "Women high in aspects of human capital, social capital, or both did not fare as well as might have been anticipated or as well as seemingly similar men." The same study found that women with strong ties to men were more likely than other women to be seen as legitimate in the technical, male-dominated MIS field. Other research has identified social networks of powerful men, from which women are excluded, as barriers for women in engineering workplaces (Faulkner, 2009a).

WORK-LIFE BALANCE ISSUES

Work-life balance is an important issue for workers, especially women, in engineering and computing. Some researchers argue that rather than work-life balance, the real issue is a "culture of overwork." Organizational cultures of overwork result in dissatisfaction among women and men (Padavic & Ely, 2013). Because culturally women are expected to fulfill the responsibilities associated with home and family and men are expected to be the breadwinners, women may experience negative outcomes as a result of this culture of overwork more frequently than men do. For example, a survey of mid-level scientists and engineers in high-tech companies found that women were more likely than men to suffer poor health and to delay or forgo getting married and having children as a result of work demands (Simard et al., 2008). When employers in male-dominated fields such as engineering and technology expect employees to work long hours (more than 50 hours per week), women with children are much more likely than men or childless women not only to leave their employer but to exit the paid workforce entirely (Cha, 2013). This research suggests that when work responsibilities become incompatible with the demands of family life, women, especially mothers, find themselves in a situation in which they must choose between work and family.

Relatively little research has explored why women leave engineering and computing fields. One study found that half of women who left corporate science, engineering, and technology jobs moved to technical jobs outside the corporate sector, and the rest moved to jobs outside STEM fields altogether (Hewlett, Buck Luce et al., 2008). Preston (2004) identified a lack of mentoring, a mismatch of interests, and difficulty balancing work and family responsibilities as reasons for leaving. Frehill (2012) found that women were more likely than men to cite a "change in career or professional interests" as the most important reason they left engineering. The first study to comprehensively investigate factors related to women's decisions to leave or stay in engineering careers (Fouad et al., 2012) is described in chapter 9. It identifies factors such as work environment and access to training and development as key to women's decisions to stay in or leave their engineering jobs.

CHALLENGING ACADEMIC WORKPLACES

Women working in academic engineering and computing jobs face challenges similar to those of other women working in engineering and computing. Women in academic STEM environments report lower job satisfaction than their male counterparts do (National Research Council, 2010; Bilimoria et al., 2008), although some evidence suggests that this gender difference in satisfaction has disappeared among engineering and computing faculty in recent years (Ceci et al., 2014). Personal experiences with sexual harassment or gender discrimination are the most likely factors to affect job satisfaction (Settles, Cortina, Malley, et al., 2006), but studies have also connected the general workplace climate—including perceptions of more work-family interference, less support, gender mistreatment, and an overall impression of the workplace as more competitive and hostile—to lower job satisfaction (Settles, Cortina, Malley et al., 2006; Marchetti et al., 2012). In one study of 765 STEM faculty members, women ranked their workplace environment more negatively than men did in six of eight measures, considering it more formal, less exciting, less helpful, less creative, more stressful, and less inclusive. Women in academic science and engineering also reported fewer conversations with colleagues about research, lower access to human and material resources, and lower recognition of accomplishments (Fox, 2010).

Some researchers have suggested that gender discrimination in academia is a thing of the past and that the remaining obstacles to women's full participation in academic STEM fields are work-family balance and pre-college decisions that result in fewer women majoring in fields such as engineering and computing (Ceci et al., 2014). Indeed, as described in chapter 1, women are less likely than men to start college intending to major in engineering or computing, and efforts to encourage girls' interest in STEM subjects may prove useful in increasing the representation of women in these fields. Likewise, some telling statistics point to the difficulties that mothers still face in academic environments. Mason and Goulden (2002) found that among science professors who became parents within the first five years after receiving a doctorate, 77 percent of the men but only 53 percent of the women had achieved tenure 12 to 14 years after earning a doctorate. These numbers support the contention that work-family balance is an obstacle to women's full participation in academic STEM workplaces. Rather than showing that gender discrimination no longer exists in academia, however, these numbers may point to environments with policies and structures that make it difficult for women with children to thrive.

While research has found that women who apply for tenure-track positions in math-intensive fields are as likely as their male peers to receive offers, qualified women are less likely than their male peers to apply for these positions (National Research Council, 2010), perhaps because they perceive academic settings as environments that will not support them in achieving their life goals. Research described in chapter 3 demonstrates that, far from being a thing of the past, gender bias in hiring is alive and well in academic environments (Moss-Racusin, Dovidio et al., 2012a).

Asian, black, Hispanic, and American Indian/Alaska Native women in academic STEM departments face additional challenges. Collecting and aggregating data on specific fields for women of color is difficult because of the low numbers, but women of color in academic science and engineering departments generally report different, and more substantial, stress than do other demographic groups. For example, women and men of color are more likely to report the stress of struggling with personal finances, women of color report more stress than both white women and men of color in lack of personal time and managing household duties, and women of color report the most stress from discrimination. Additionally, 79 percent of women of color responded affirmatively to the statement "I need to work harder to be perceived as a legitimate scholar," compared with 67 percent of white women, 60 percent of men of color, and 52 percent of white men (National Academy of Sciences, 2013).

STEREOTYPES AND BIASES

Stereotypes and biases are important cultural factors that may influence women's representation in engineering and computing. A stereotype is an association of specific characteristics with a group (Dovidio et al., 2010). Stereotypes can be descriptive (what women and men *are* like) or prescriptive (what women and men *should* be like). Everyone uses stereotypes to process new information quickly, assess differences between individuals and groups, and make predictions. Stereotypes allow us to use fewer cognitive resources than we would if we made individual observations each time we met someone new (Heilman & Eagly, 2008; Heilman, 2012). Indeed, human beings have been described as "cognitive misers" who are reluctant to engage in effortful thought unless absolutely necessary (Fiske & Taylor, 1991). For this reason, stereotypes are very powerful and difficult to override, and they can lead to biased behavior or discrimination when we view members of a group based on their group status rather than as individuals (Heilman, 2012; Dovidio et al., 2010).

Gender stereotypes tend to place greater social value on men and evaluate men's competence as greater than women's (Ridgeway 2001). One specific area in which men are stereotypically deemed more competent than women is mathematics. Parents' and teachers' expectations for children's mathematical achievement are often gender-biased and can influence children's attitudes toward math (Gunderson et al., 2012; Varma, 2010). Parents' and teachers' own feelings about math can rub off on children. In one study, no relationship was found between first and second grade female teachers' math anxiety and their students' math achievement at the beginning of the school year. By the school year's end, however, the more anxious female teachers were about math, the more likely girls (but not boys) in their class were to endorse the commonly held stereotype that "boys are good at math, and girls are good at reading" and the lower these girls' math achievement was (Beilock et al., 2010).

WARMTH VERSUS COMPETENCE

While men are stereotypically thought of as competent in many domains, women are stereotypically considered to be warm. Competence and warmth are traits that we tend to immediately assign to people we meet, and these traits are often perceived to be in opposition to each other (Holoien & Fiske, 2013). Because competence is valued in engineering and computing, the requirements for being viewed positively as a technical professional and being viewed positively as a woman are often conflicting. As a result, many women in technical roles report difficulty forging strong identities as engineers or computing professionals (Hatmaker, 2013; Faulkner, 2007, 2009a, 2009b; Ayre et al., 2013), and many female engineers describe an increased pressure to prove themselves (Hatmaker, 2013; Smith, L., 2013). When women emphasize their competent characteristics and effectiveness at work, they often experience backlash for violating the gender stereotype that women are warm, and they are seen as less likeable than men who emphasize the same behaviors, especially in male-dominated fields (Phelan et al., 2008; Rudman & Phelan, 2008; Heilman, Wallen et al., 2004). On the other hand, women seen as warm but not competent are less likely to be respected and more likely to be pitied and socially neglected in the workplace (Fiske, 2012; Cuddy et al., 2007).

MICROINEQUITIES

By the time women begin formal engineering or computing training in college, they likely have encountered gender-biased behavior on many occasions. Microinequities have been described as "apparently small events … frequently unrecognized by the perpetrator … which occur wherever people are perceived to be 'different'" (Rowe, 2008, p. 45). Examples include facial expressions, gestures, tone of voice, and subtle actions, such as assigning the role of note taker to a woman rather than a man. Accumulated over time, these microinequities can affect students' self-concept, which may, in turn, influence their choice of a career (Rowe, 1990; Bandura, 1997).

Camacho and Lord (2011) found that female engineering undergraduates frequently encounter gender-based "microaggressions," small discriminatory behaviors of mostly nonphysical aggression (Pierce, 1970), in the engineering education environment. Such behaviors include encountering surprise that a woman would be interested in engineering, having male students interrupt or speak over them, experiencing difficulty having their ideas heard, being exposed to sexual discussions and joking, hearing suggestions that women are in the department only as a result of affirmative action policies rather than because of their achievements and abilities, and hearing gendered statements by professors during lectures. Other research indicates that microinequities persist long after women enter the engineering workforce (Faulkner, 2009b).

Microinequities illustrate how discrimination in school and the workplace is often subtle and not overt in its intent to harm (Hebl et al., 2002). Nonetheless, microinequities may result in increased stress and feelings of exclusion among women in engineering (Camacho & Lord, 2011).

GAMERGATE

Aggression against women is not always subtle. The Gamergate controversy of 2014 dramatically illustrates the virulence of gender bias in the video gaming industry. The controversy began with an ex-boyfriend's postings about the journalistic ethics of his ex-girlfriend, a prominent game developer. These allegations led to an intense flurry of postings in online forums and on social media, which quickly devolved into sexist attacks against the female gamer and against women in the industry. Female gamers were barraged by hostile postings and messages, and some were subjected to threats of rape and death that resulted in the women fleeing their homes. One even received bomb threats as a result of her work as a feminist critic of gaming. Gamergate is a chilling example of the serious online and real-world harassment and aggression that some women face in traditionally male technical realms.

EXPLICIT AND IMPLICIT BIAS

Biases can be explicit (conscious and self-reported on surveys or in interviews) or implicit (operating automatically, typically outside an individual's conscious awareness). Explicit gender bias has been steadily declining for decades. Whether due to a genuine increase in egalitarian beliefs or to a greater hesitation to express biased attitudes (or some combination of the two), people are less likely today to say that they hold biased beliefs than they were in the past (Banaji & Greenwald, 2013). In contrast, implicit gender biases remain pervasive (Nosek, Banaji et al., 2002b; Lane et al., 2012; Smyth, Greenwald et al., 2015; Dovidio, 2001). Even individuals who consciously reject gender stereotypes often still hold implicit gender biases. In socially sensitive domains involving topics such as race or gender, some evidence indicates that implicit bias is a better predictor of behavior and judgment than is explicit bias (Greenwald, Poehlman et al., 2009). Implicit and explicit biases are related to each other but understood by psychologists to operate via distinct and different psychological mechanisms (De Houwer et al., 2009; Nosek & Smyth, 2007; Nosek, 2007). Because implicit bias is widespread and the prevalence of explicit bias is declining, this chapter focuses more on implicit bias.

The concept of implicit bias was introduced in 1995, when social psychologists Anthony Greenwald and Mahzarin Banaji built on the psychological concept that our actions are not always under our conscious control. They argued that much of our behavior is driven by stereotypes that operate automatically and, therefore, unconsciously. Researchers theorize that, starting at an early age, we acquire implicit biases simply by living in a society where different types of people fill different roles and jobs (Cvencek, Greenwald et al., 2011; Cvencek & Meltzoff, 2012). Passive exposure to widespread beliefs registers these beliefs in our minds without our even knowing it. For this reason, implicit attitudes and beliefs may be better described as reflections of the surrounding environment rather than personal attributes (Dasgupta, 2013).

Once in place, implicit biases lead us to seek evidence that supports them and question or disregard evidence that contradicts them (Schmader, 2013). When we encounter another person, we instantly view her or him as a woman or man, and our views of any other characteristics that person may have are shaped by our beliefs about what she or he is and should be like as a woman or a man (Hassan & Hatmaker, 2014; Ridgeway, 2009). For example, a number of qualitative studies conducted in engineering workplaces found that women are often not seen by their co-workers and colleagues as full-fledged members of the engineering profession (Tonso, 2007; McIlwee & Robinson, 1992; Faulkner, 2009b)—they are "highly visible as women yet invisible as engineers" (Faulkner, 2009b, p. 169).

In 1998 Greenwald and his colleagues introduced the Implicit Association Test (IAT), a measure designed to detect the strength of a person's automatic association between two concepts. Today many IATs are freely available online at implicit.harvard.edu. One IAT that is especially relevant to women in engineering and computing is the gender-science IAT, which measures the strength of associations between gender and science. Using a computer, participants quickly sort words in each of two conditions: a gender-stereotypical condition and a counter-stereotypical condition. In the stereotypical condition, subjects use the same keyboard key to categorize items representing male (for example, the word "father") and science (for example, the word "physics") and another key to categorize items representing female (for example, "mother") and liberal arts (for example, "literature"). Next, individuals categorize the same words paired in a counter-stereotypical way, for example, male and liberal arts sorted with one key and female and science items with a different key. Which condition is presented first is randomly varied across participants. A participant's score is based on the difference in the speed and accuracy of sorting between the two conditions.

Both women and men, on average, have a strong tendency on the IAT to more readily associate male with science and female with humanities than the reverse (Nosek, Banaji et al., 2002a, 2002b; Smyth, Greenwald et al., 2015), and implicit associations that pair boys and men with math have been documented in the United States in children as young as age 7 (Cvencek, Meltzoff et al., 2011).

GUIDANCE COUNSELORS

Although the relationship between gender and vocational interests is complicated, evidence suggests that career inventory surveys currently prevalent in high school academic and career counseling may have a gender bias. Studies have found that the RIASEC Inventory, the survey most commonly used by career counselors today, may be better suited to male students than to female students and may lead to different occupation recommendations for girls and boys (Kantamneni & Fouad, 2011; Armstrong et al., 2010).

One study found that a sample of guidance counselors in Utah perceived the values, interests, and qualities of students differently based on gender. Many counselors also showed an "alarming" lack of knowledge about engineering educational and career paths and were unprepared to inform students about engineering opportunities (Iskander, 2013). Other research found that some guidance counselors in the southwest were very much aware that women are underrepresented in STEM occupations and that girls are negatively affected by gender-science stereotypes (Ross, 2012). Understanding more about guidance counselors' gender biases, knowledge of engineering and computing careers, and awareness of the influence of gender biases may help identify ways for them to better help girls make informed educational and career choices.

Most studies that examine the practical impact of implicit biases as measured by the IAT have focused on race and not gender (Banaji & Greenwald, 2013). A few examples of the behaviors found to be predicted by individuals' implicit preference for white people include less comfort and less friendliness when talking with a black interviewer than a white interviewer (McConnell & Leibold, 2001), greater readiness to perceive anger in black faces than white faces (Hugenberg & Bodenhausen, 2003), and greater likelihood to laugh at racial humor and rate it as funny (Lynch, 2010). Green and colleagues (2007) found that physicians with greater implicit racial biases favoring whites recommended optimal treatment for acute cardiac symptoms more often for a white patient than for a black patient. These studies provide evidence that implicit biases are correlated with discriminatory behavior and appear to have real-world implications.

While less research has explored the effects of implicit gender biases as measured with the IAT, recent evidence described in chapter 3 finds that implicit gender-math bias is linked to gender discrimination. Gender bias coupled with racial/ethnic bias presents a particularly challenging environment for women of color in engineering and computing (Ong, Wright et al., 2011). Further study is needed about the connection between implicit biases related to women in science and math as measured with the IAT and actual behaviors toward women in engineering and computing.

BIASED EVALUATIONS

Biased evaluations play an important role in the professional opportunities afforded to women. Even before the formal application process begins, biased evaluations can affect women's chances of getting a position. One study found that professors from many different fields were less likely to respond to an e-mail informally inquiring about research opportunities from a prospective applicant to a doctoral program if it had a woman's name on it (Milkman et al., 2014).

Hiring situations are particularly vulnerable to bias because hiring managers are generally working with limited information under time constraints, and employers typically have little opportunity to reconsider a decision after it has been made (Bendick & Nunes, 2012). Once applicants reach the interview stage, women in typically male fields face additional challenges, such as negative body language from interviewers, that can affect interview performance (Hess, K. P., 2013).

Biased evaluations continue to affect women once they have been hired. Female managers receive lower ratings on performance reviews than male managers do and are held to a higher standard, needing better performance ratings than their male peers to be promoted (Lyness & Heilman, 2006). In male-dominated science and engineering fields women are less likely than men to be seen as experts by their colleagues and to serve in important roles on teams (Joshi, 2014). Managers' discretion over everyday decisions, such as how to execute company human resource policies, can be influenced by gender biases, resulting in diminished opportunities for women and increased opportunities for men (Roth & Sonnert, 2011; Ayre et al., 2013; Bobbitt-Zeher, 2011; Catalyst, 2008; Fouad et al., 2012; Williams, C. L., et al., 2012). For example, women are less likely than men to be granted requests for flexible schedules, and that lack of workplace flexibility can prevent women, especially working mothers, from furthering their careers (Brescoll, Glass et al., 2013).

Castilla and Benard (2010) identified the "paradox of meritocracy," in which managers in organizations explicitly identified as meritocratic favor and reward male employees more generously than equally qualified female employees. This finding may have particular relevance for engineering and computing. More engineers and technical professionals, including organizational leaders, may believe that their workplaces are meritocratic than do professionals in fields that are less data-oriented. One study of scientists and engineers at high-tech companies, however, found that women were less likely than men to see their workplaces as meritocracies, perceiving connections to power and influence as necessary for advancement (Simard et al., 2008).

IN-GROUP FAVORITISM

Research suggests that biased behavior or discrimination today most often results from "in-group" favoritism, or giving preferential treatment to others with whom we identify in some way, as opposed to negative treatment of "out-group" members of groups with whom we don't identify. Laboratory and field studies find that discrimination involving the absence of positive treatment happens in many instances without any accompanying specifically negative treatment and is, in fact, more common than discrimination that involves outright hostility (Greenwald & Pettigrew, 2014). This research suggests that in-group favoritism is an important mechanism by which unequal group outcomes—including unequal outcomes for women—are maintained and is, therefore, a practice that individuals trying to reduce discrimination should minimize.

Still, if more women moved into leadership roles in engineering and technical fields, it is possible that in-group preferences could result in even more women moving into these fields. Kurtulus and Tomaskovic-Devey (2012) found that an increase in the share of female top managers in an organization was associated with subsequent increases in the share of women in mid-level management positions in that organization, particularly female managers within the same racial/ethnic group as that of the top managers.

EVEN MEN ARE AFFECTED BY GENDER BIASES AGAINST WOMEN

Gender biases can create obstacles not only for women in technical workplaces but also for the men who work with them. In one study of equally performing teams working on a male-typed task, teams with a higher percentage of women rated both their female and male peers' work more negatively overall and expressed less desire to work together in the future (West et al., 2012). Another study found that in a typically male field, people rated their male colleagues as less masculine and less deserving of workplace success if they had female supervisors (Brescoll, Uhlmann et al., 2012). This research sheds light on the magnitude of the problem of gender bias in predominantly male fields and perhaps points to one mechanism by which it is maintained. If men's work is devalued when men work with women, men might take steps to avoid working with women, exacerbating the challenges facing women in male-dominated fields. While diversity has demonstrated benefits, there are real challenges to achieving it.

SEXISM

Sexism can be either hostile or "benevolent." Benevolent sexism is rooted in a belief that women need the help and protection of men (Glick & Fiske, 1996; Fiske, 2012). Women who are seen as warm but not competent are especially likely to be the recipients of benevolent sexist behaviors such as being called "sweetheart" or being offered help with dangerous aspects of a job. While on the surface benevolent sexism may seem positive toward women, its effects are quite the opposite.

In one study, participants looked at a job interview transcript in which a male interviewer showing hostile sexism (such as a belief that women are incompetent), benevolent sexism (such as a belief that women should be protected), or no sexism interviewed a female candidate for a stereotypically male job. Researchers found that the more participants reported liking the sexist interviewer, the less competent and deserving of the job the participants found the candidate (Good, J. J., & Rudman, 2010). Importantly, observers more frequently liked the benevolent sexist than the hostile sexist interviewer, and observers need not have held sexist beliefs themselves to like the sexist interviewer.

When a leader in an organization is sexist, women can face particularly challenging circumstances. Good and Rudman explain:

> The more a sexist boss is liked by co-workers and upper level management, the less competent female employees may seem as a result of his sexist treatment. Because benevolent sexism is often not viewed as sexist

> … and in some cases is viewed as positive, chivalrous behavior … it is plausible that benevolent sexists are often viewed more favorably than hostile sexists, as was the case in the present study. As a result, women may be especially vulnerable when targeted for benevolent sexism because the perpetrator is often viewed positively, even though his treatment can undermine female recipients.

Benevolent sexism has also been shown to result in women receiving fewer challenging assignments, which can limit career development and advancement (King et al., 2012). Whether sexist behavior is more prevalent in engineering or computing workplaces than elsewhere is not clear. Still, evidence shows that women experience more sex discrimination in workplaces where they make up less than one-fourth of the workers (Stainback et al., 2011), and research described in chapter 4 finds that men in engineering and computing fields tend to have higher explicit and implicit gender-science biases than do men in other fields (Smyth, Greenwald et al., 2015).

SEXUAL HARASSMENT

Sexual harassment, defined broadly as unwelcome conduct of a sexual nature, can include behaviors such as direct and unwanted sexual advances and physical contact or a hostile work environment that includes sexual and sex-based taunting, comments, or denigration (Berdahl, 2007). Sexual harassment is widespread in engineering and technology (Servon & Visser, 2011; Faulkner, 2009a). One recent study of college-educated women in the private science, engineering, and technology sector found that 63 percent of women in engineering and 51 percent of women in technology had experienced sexual harassment (Hewlett, Sherbin et al., 2014). Organizational climate is a major factor in the prevalence of sexual harassment in the workplace (O'Leary-Kelly et al., 2009). Studies suggest that male workers in male-dominated fields may harass their female co-workers as a way to protect their territory when they sense that women are encroaching on male space (Berdahl, 2007; Chamberlain et al., 2008; McLaughlin et al., 2012).

Because of its pervasiveness, sexual harassment can seem "normal," and women may hesitate to report it, opting instead to employ coping mechanisms such as tuning it out or thinking of it as a necessary evil. Denissen (2010) documented how women in the building trades prioritized maintaining good relationships with their co-workers above reporting sexual harassment, attempting to ignore the persistent harassing behavior because of possible repercussions. In a study of technology workplaces, Hunter (2006) found similar challenges for women, where female employees chose not to report sexual harassment and tried to downplay their femininity to "fit in."

The consequences of sexual harassment are tangible and troubling. Personal or observed experiences with sexual harassment or gender discrimination are associated with alienation and low job satisfaction (Settles, Cortina, Buchanan et al., 2013; Settles, Cortina, Malley et al., 2006). Women who are targets of workplace incivility such as sexual harassment are more likely to consider quitting their jobs and dropping out of their career fields (Cortina, Magley et al., 2001). Sexual harassment can affect mental and physical well-being through increased stress, anxiety, and depression and lowered self-esteem (Bowling & Beehr, 2006). These effects extend beyond the employees targeted by harassers. Female and male employees who witness gender-based hostility at work also express greater organizational withdrawal and lower well-being (Miner-Rubino & Cortina, 2007).

Not all women are equally vulnerable to sexual harassment. Women of color are more likely to experience sexual harassment as well as racial/ethnic-based harassment (Berdahl & Moore, 2006; Cortina, Kabat-Farr et al., 2013). Additionally, women in positions of authority are more likely to report harassing behaviors than are women in nonsupervisory positions, which supports the idea that sexual harassment may be connected to dominance and control (McLaughlin et al., 2012; Stainback et al., 2011; Chamberlain et al., 2008). The negative effects of workplace harassment are mitigated in workplaces where women believe that they have a strong organizational voice (Settles, Cortina, Stewart et al., 2007).

HOW STRUCTURAL AND CULTURAL BARRIERS AFFECT WOMEN

The factors described above have tangible effects on women in engineering and computing. From influencing girls' and women's preferences to their sense of belonging in these fields, cultural and structural elements, including stereotypes, biases, microinequities, and sexism, shape girls' and women's experiences in engineering and computing.

STEREOTYPES INFORM PREFERENCES

Gender biases affect not only how we view and treat others but also how we view ourselves and the choices we make about our own futures. From early childhood, cultural stereotypes guide our choices and behavior, steering us toward certain careers that seem to be the best fit for our interests and abilities and away from others. Studies suggest that girls who associate mathematics with boys and men are less likely to perceive themselves as being interested in or skilled at mathematics and spend less time studying or engaging with mathematics concepts. As early as first grade, children have already developed a sense of gender identity, and most have developed implicit biases associating boys with math as well (Cvencek, Meltzoff et al., 2011).

As described in chapter 4, individuals' implicit biases are related to their college majors, with women in science and engineering exhibiting particularly weak, and men in those fields exhibiting particularly strong, science-male implicit biases (Smyth, Greenwald et al., 2015; Nosek & Smyth, 2011; Lane et al., 2012; Smeding, 2012). Although the causal direction is not known, researchers suspect that implicit biases likely influence the choices that women and men make, while at the same time the environments in which women and men are immersed shape their implicit biases.

Jacquelynne Eccles, a leading researcher in the field of occupational choice, has spent the past 35 years developing a model and collecting evidence about career choice (Eccles [Parsons] et al., 1983; Eccles, 1994, 2007). She found that women are less likely than men to enter occupations such as engineering and computing because they have less confidence in their math and physical science abilities and because they place less subjective value on these fields than they place on other occupational niches (Eccles, 2011b).

Many researchers have found a perceived difference in the value that women and men place on doing work that contributes to society, with women, on average, more likely than men to prefer work with a clear social purpose (Jozefowicz et al., 1993; Margolis, Fisher, & Miller, 2002; Lubinski & Benbow, 2006; Eccles, 2007). A meta-analysis of job-attribute preferences found that the largest gender differences in desired job characteristics are related to communal goals, that is, helping other people and working with people, with women expressing a greater preference for both (Konrad et al., 2000). As described in chapter 6, engineering and computing careers are perceived by most people as inhibiting communal goals, and individuals who highly endorse communal goals are less likely to express interest in these fields (Diekman, Brown et al., 2010).

If women perceive engineering and computing as fields that will not allow them to meet highly valued goals, it is not surprising that they might choose other career paths, even other STEM career paths (Benbow, 2012). Eccles and her colleagues found that the desire at age 20 to have a job that helps people is a very strong predictor of both women and men completing a major in the biological rather than the physical sciences or math and working in biological or medical occupations rather than physical science or engineering occupations at age 25 (Eccles, 2009, 2011a, as reported in Kimmell et al., 2012). In the same vein, Harrison and Klotz (2010) found that the percentage of women in sustainability leader positions in design and construction companies, a position that explicitly connects engineers' contributions to problems such as energy and water resource depletion, climate change, and social inequity, is much higher (39 percent) than the percentage of women in general management positions (8 percent) in those same companies.

Eccles (2011b) points out that women (and men) likely do not consider the full range of options when choosing a career. Many options may never be considered because women are unaware of their existence. For example, Google (2014b) identified exposure to computing as a leading factor in women's choice to pursue computing. Even when girls and women are aware of career options, they may not seriously consider those options because women have inaccurate information regarding either the option itself or their ability to achieve in that field. For example, Teague (2002) found that the issues that deter many women from pursuing computing occupations are not supported by the actual experiences of the women working there. Women may not seriously consider other careers because these options do not fit well with their ideas of what is appropriate work for women, further reducing women's perceptions of the field of viable options.

Focusing on girls' and women's choices might seem to "blame the victim"—women—for their underrepresentation in engineering and computing. According to sociologist Maria Charles (2011, p. 25), however, acknowledging gender differences in educational and career choices doesn't blame women for women's underrepresentation in engineering and computing unless preferences and choices are understood purely as a reflection of individuals' intrinsic qualities, separate from the social environment in which preferences emerge:

> The argument that women's preferences and choices are partly responsible for sex segregation doesn't require that preferences are innate. Career aspirations are influenced by beliefs about ourselves (what am I good at and what will I enjoy doing?), beliefs about others (what will they think of me and how will they respond to my choices?), and beliefs about the purpose of educational and occupational activities (how do I decide what field to pursue?). And these beliefs are part of our cultural heritage. Sex segregation is an especially resilient form of inequality because people so ardently believe in, enact, and celebrate cultural stereotypes about gender difference.

Recent analyses of international differences in the composition of engineering and computing fields make clear that the surrounding culture makes a difference (Frehill & Cohoon, 2015; Charles, 2011). While in the United States approximately one-fifth of computer science degrees are awarded to women, in Malaysia women earn about half of computer science degrees. Similarly, engineering is the most strongly and consistently male-typed field of study worldwide, but the gender composition of engineering varies widely across countries. In the United States fewer than one-fifth of engineering degrees are awarded to women, but in Indonesia women earn just under half of engineering degrees. Women make up about a third of recent engineering graduates in a diverse group of countries, including Mongolia, Greece, Serbia, Panama, Denmark, Bulgaria, and Malaysia (Charles, 2011).

In the United States and other industrialized countries, individuals and especially girls are encouraged to choose careers based on self-expression and self-realization, whereas in developing countries personal economic security and national development are often much more central concerns to young people and their parents. Perhaps ironically, this allows women in countries such as the United States more opportunity to conform to gender stereotypes in their career choices (Charles & Bradley, 2009; England, 2010).

STEREOTYPE THREAT

In addition to affecting preferences, stereotypes affect women through a phenomenon known as stereotype threat. Stereotype threat describes a threat—sometimes referred to as an anxiety—that people experience when they fear being judged in terms of a group-based stereotype (Steele, 1997; Steele & Aronson, 1995). One need not believe the stereotype nor be worried that it is true of oneself to experience stereotype threat and its negative effects. To be susceptible, individuals must only be aware of the stereotype, identify with the group that is stereotyped, and care about succeeding in the domain in which the stereotype applies

(Steele, 1997). For this last reason, people who care the most about succeeding in a domain may experience the highest levels of stereotype threat. Robust gender-math stereotypes in U.S. culture make stereotype threat an important phenomenon in understanding women's underrepresentation in engineering and computing.

Stereotype threat has many negative effects, including physiological stress responses such as a faster heart rate, increased cortisol levels, and increased skin conductance related to increased monitoring of one's performance and efforts to regulate unwanted negative thoughts and feelings. These extra processes are understood to "hijack cognitive resources" (Schmader & Croft, 2011, p. 792)—specifically working memory capacity—needed for successful performance (Schmader, 2010; Schmader, Forbes et al., 2009; Schmader, Johns et al., 2008; Schmader & Johns, 2003). Stereotype threat has been shown to result in decreased math performance among women (Koch et al., 2014; Spencer et al., 1999; Nguyen & Ryan, 2008; Walton & Spencer, 2009; Good, C., Aronson et al., 2008), decreased interest and motivation in STEM fields among women (Davies et al., 2002), and decreased sense of belonging (Walton & Cohen, 2007). It ultimately may result in disidentification with the stereotyped domain (Steele, Spencer et al., 2002; Steele, 1997). Stereotype threat can be particularly harmful to women of color because they have to contend with the threat of confirming stereotypes based on both race and gender (Settles, 2004).

Stereotype threat is triggered by cues from the environment that alert an individual to the possibility of confirming a negative stereotype about a group to which she or he belongs. Cues are often quite subtle. For example, being a member of a minority group, as women in engineering and computing often are, in and of itself can trigger a sense of threat. In one study female STEM majors who viewed a video of a scientific conference with noticeably more men than women in attendance exhibited higher indications of stereotype threat and reported a lower sense of belonging and less desire to participate in the conference compared with women who viewed a similar video with a gender-balanced group of attendees (Murphy et al., 2007). In another experiment, subtle sexist behavior by men triggered stereotype threat in female engineering majors resulting in their underperformance on a math, but not a verbal, test (Logel et al., 2009).

Another study found that when watching a video in which a woman was subjected to dominant behavior, including command statements like "you need to..." combined with gesturing and a relaxed posture by a man in a math context, female participants showed reduced math performance and reported greater worry about confirming the negative stereotype that women are not as good as men at math. When women watched a video in which the man and woman were equal in dominance or the woman was dominant over the man, however, female participants did not experience stereotype threat (Van Loo & Rydell, 2014). This last finding demonstrates the potentially far-reaching benefits of encouraging equality and female leadership in the classroom and workplace, because seeing women in leadership roles can actually protect other women from the harmful effects of stereotype threat.

Until recently, research on stereotype threat focused primarily on the effect of stereotype threat on academic performance in the learning environment. Researchers are just beginning to explore the effects of stereotype threat in the workplace, focusing less on performance measures and more on measures of psychological disengagement, such as the degree to which women and men might say they feel disconnected from their work or mentally exhausted at the end of the day. A study described in chapter 5 found that the more female science faculty members discussed research with male colleagues, the more disengaged women felt from their work. The more women socialized with their male colleagues, on the other hand, the more engaged women felt with their work (Holleran et al., 2011). The researchers hypothesize that research conversations with male colleagues may trigger stereotype threat among female scientists, whereas social conversations may increase feelings of belonging and, therefore, reduce experiences of stereotype threat.

Because the effect of stereotype threat in the learning environment has been so clearly and repeatedly demonstrated, it is evident that stereotypes can affect stereotyped individuals in important ways. Understanding how stereotype threat affects women in the workplace, especially in fields such as engineering and computing, is an important area for future research.

SENSE OF BELONGING

Perhaps because of all these factors taken together, women often report feeling that they don't belong in engineering and computing fields (Ayre et al., 2013; Faulkner, 2009b). Research described in chapter 8 shows that even among first-year engineering students, women are less likely to perceive engineering as the right career for them (Cech, Rubineau et al., 2011).

A sense of belonging in a particular setting or broader field is associated with a variety of positive outcomes for individuals (Walton, Cohen et al., 2012; Walton & Cohen, 2007). For example, a brief intervention aimed at increasing first-year college students' sense of social belonging was found to positively affect participants' GPA and self-reported health and well-being (Walton & Cohen, 2011). Even more relevant, women participants in a social-belonging intervention who learned that adversities and worries about belonging were common for all engineering students raised their engineering GPAs, improved their academic attitudes, and viewed their daily adversities as more manageable (Walton, Logel et al., 2014). In another study, women showed improved scores on math tests if they wrote a brief essay about social belonging beforehand (Shnabel et al., 2013). Finally, a series of lab studies found that sense of belonging in math is a good predictor of whether women will continue to take math courses (Good, C., Rattan et al., 2012). Sense of belonging can have important effects even when individuals are unconscious of it. In some of the above studies, participants indicated no awareness of the intervention's impact (Walton & Cohen, 2011).

WHERE DO WE GO FROM HERE?

The chapters that follow examine specific research findings on pivotal issues affecting the representation of women in computing and engineering. The results suggest that with small and large changes in education and the workplace, progress can be made for the existing generation of women in these fields as well as future generations.