Adultspan Journal

Volume 13 | Issue 1 Article 4

4-1-2014

# Psychological Barriers to STEM Participation for Women Over the Course of Development

Jennifer Saucerman

Kris Vasquez

# Psychological Barriers to STEM Participation for Women Over the Course of Development

## Keywords

women, STEM, barriers, psychological factors

Received 09/05/12
Revised —
Accepted 04/08/13
DOI: 10.1002/j.2161-0029.2014.00025.x

# Psychological Barriers to STEM Participation for Women Over the Course of Development

**Jennifer Saucerman and Kris Vasquez**

*Women continue to be underrepresented in science, technology, engineering, and mathematics (STEM). This literature review examines psychological factors over the course of development that contribute to the ongoing underrepresentation of women in these fields. The authors present fundamental principles that pose barriers to women in STEM.*

"Math class is tough!" complained Teen Talk Barbie dolls in 1992. The now-notorious statement spurred controversy in the science, technology, engineering, and mathematics (STEM) community, resulting in Mattel's offering to trade an inoffensive version of the doll for the ones that were programmed to say the phrase ("Mattel Says," 1992). In a letter addressing the controversy, Mattel's president indicated that, although the company considered the statement to be a sentiment shared by many male and female students, "We didn't fully consider the negative implications of this phrase."

Perhaps the doll would not have been the target of criticism if it were not released in a society in which boys continually outscore girls in STEM-related advanced placement exams (American Association of University Women [AAUW], 2010), teachers evaluate their male students' mathematical ability as being higher than that of female students despite performance measures that indicate roughly equal ability (Tiedemann, 2000), and women are considered less likable for demonstrating competence in a predominantly male discipline (Heilman, Wallen, Fuchs, & Tamkins, 2004). Hearing "Math class is tough!" from a child's doll is particularly troubling for numerous parents, educators, and researchers because they understand how its message operates within a social context that repeatedly discourages women and girls from entering and succeeding in STEM fields.

---

*Jennifer Saucerman, Department of Educational Psychology, University of Wisconsin; Kris Vasquez, Department of Psychology, Alverno College.* *This work was supported by the Alverno College Research Center for Women and Girls. Joomi Lee provided substantial assistance in gathering information for several sections of this report. The authors thank Jim Henderson, Justin LaManna, and Cory Masiak for their comments on this article.* *Correspondence concerning this article should be addressed to Jennifer Saucerman, Department of Educational Psychology, University of Wisconsin, Educational Sciences Building, 1025 West Johnson Street, Room 499D, Madison, WI 53706 (e-mail: jenny.saucerman@gmail.com).*

From early childhood to adulthood, women and girls encounter overt and subtle messages that lead them to believe that failures in STEM disciplines are due to a lack of ability (Dickhauser & Meyer, 2006), that men are naturally more talented in STEM fields, and that identifying oneself as feminine is at odds with identifying as a professional in STEM fields (Pronin, Steele, & Ross, 2003). Understanding these deterrents is an important first step in finding effective interventions that increase female participation in adulthood.

The purpose of this article is to identify social psychological barriers to STEM field participation, organized by developmental stage. We address general processes that in some cases have only been studied in particular subfields of STEM. Where possible, we note the specific topic of the investigation. We recognize that some STEM fields have significantly more participation by women than others, but, given the focus of this article, we concentrate on general findings rather than on a detailed analysis of how each barrier applies to subfields. Therefore, we invite the reader with expertise in specific STEM areas to consider to what degree these potential problems are reflected in her or his field.

## EARLY CHILDHOOD

Young children perceive messages about social roles, their own competence, and possibilities for their future, both from overt instruction and from subtle, even unconscious, influences. These lessons by themselves will not determine a child's ultimate career, but they help to establish the context in which later messages will be interpreted.

### Parental Influence

Parents influence children's ideas about math and science far earlier than they may realize. Through daily life and through media, children are exposed to mathematical and scientific concepts before they even enter school. Incoming preschoolers vary greatly in their mathematical knowledge (Starkey, Klein, & Wakeley, 2004), which appears to have an impact on their later academic achievement (Lee & Burkam, 2002). (Note: Arguably, children are also exposed to technological concepts at this age, although because there have not been any psychological studies documenting young children's technological usage, this content area will not be discussed here.) One factor that may contribute to this variation is parental "number talk"—discussions in which parents engage their children in counting and number matching. A longitudinal study by Levine, Suriyakham, Rowe, Huttenlocher, and Gunderson (2010) found that the frequency in which parents engaged in number talk with their 14- to 30-month-olds varied greatly among families and that the variation predicted children's understanding of the cardinal meanings of numbers at 46 months of age.

If Levine et al.'s (2010) study showed that talking about mathematical concepts is important to developing understanding in children, then it is logical to ask whether boys and girls experience the same extent of this kind of communication. Levine et al.'s study did not address that question, but other researchers have examined gender differences in parental explanations of scientific principles in the context of informal science activities. In a naturalistic observation of parents and their children at a California children's museum, researchers found that parents provided at least one scientific explanation in 29% of their interactions with their sons as opposed to 9% of their interactions with their daughters, despite the fact that boys were not significantly more likely to initiate interactions than girls (78% and 74%, respectively). The differences in explanation frequency by child's gender were the greatest in father–child dyads; that is, whether fathers spoke often or seldom to their children about scientific concepts, they were much less likely to speak to a daughter about them than to a son (Crowley, Callanan, Tenenbaum, & Allen, 2001).

Because children who do not receive adult explanations of scientific phenomena are unlikely to develop their own explanations (Crowley & Siegler, 1999), parental guidance in scientific conversation is an important source of science ideas for young children. The results of these studies as a whole suggest that it is possible that, without any conscious intention by parents, young girls are entering school with less exposure to and understanding of mathematical and scientific principles than their male counterparts. Preschool exposure cannot be considered the only barrier to STEM interest, of course, but these studies suggest that girls and boys may not begin school with an "even playing field" when it comes to these subjects.

### Teacher Influence

Teachers who deal with young children can communicate messages about their own attitudes regarding science and math, without being aware of doing so. At the college level, elementary education majors report the highest level of math anxiety of all college majors (Hembree, 1990). Some of the anxiety may be related to inexperience with mathematics; few kindergarten through second-grade teachers have taken advanced courses in mathematics in college, such as statistics (33%) or geometry for elementary and middle school teachers (19%); far fewer report taking calculus (13%; Malzahn, 2002).

These math attitudes and experiences have surprisingly powerful effects on students. Female teachers' math-related anxiety is associated with lower mathematical achievement among female students and with increased likelihood of students endorsing traditional notions of academic ability (Beilock, Gunderson, Ramirez, & Levine, 2010). More specifically, in a study of 17 first- and second-grade classrooms, there was no relationship found between the teachers' math anxiety and students' initial math proficiency. However, by the end of the year, there was a significant inverse relationship between teachers' math anxiety and female students' achievement; the more math anxiety a teacher reported, the lower the girls' scores (this pattern was not found for male students). High teacher math anxiety was also found to be positively correlated with female students' beliefs in traditional gender abilities—the idea that boys are good at math and girls are good at reading. Moreover, the more girls endorsed this gender-typed thinking, the lower they scored on the math assessment at the end of the school year.

Because no gender difference in mathematical achievement was found at the beginning of the school year, and because female endorsement of traditional gender abilities was correlated with female mathematical achievement, researchers speculated that teachers' math anxiety must be influencing girls' beliefs about math and gender, which, in turn, affected girls' math performance. They pointed to evidence that young children model the behaviors of same-sex adults that children perceive to be gender appropriate (Perry & Bussey, 1979). This model would help explain why female students are most negatively affected by female teachers' math anxiety, because the students' same-sex adult role models are demonstrating gender-related behaviors that conform to traditional gender roles.

None of this research implies that teachers intend to convey messages about gender stereotypes or math anxiety to the students or that they are even aware that they are doing so. Psychologists have found strong evidence that implicit attitudes—that is, attitudes held by the subconscious mind that are not available to conscious awareness—can have profound effects on behavior (e.g., Friese, Hofmann, & Schmitt, 2008). The teachers may, in many cases, be reflecting implicit attitudes that they formed through processes similar to what has been described above during their own childhoods. Such implicit attitudes can cause the teachers' behavior to differ in subtle but powerful ways as they interact with female and male students.

## CHILDHOOD

### Ability Beliefs of Teachers and Parents

Teachers continue to influence STEM attitudes as students progress through elementary school. For example, on average, teachers of 8- to 12-year-olds evaluate girls' math ability as lower than boys' ability, despite the fact that young boys and girls perform at roughly the same level, on average (Dickhauser & Meyer, 2006). Teachers also have a tendency to attribute the mathematical success of boys less to high effort, and more to high ability, compared with girls. Teachers often assume that male students have a higher logical-thinking ability.

Teachers are not the only source of feedback about ability in STEM and may be reflecting societal stereotypes rather than creating them. However, regardless of the ultimate source of the message, it is not surprising that elementary-age boys and girls hold different beliefs about their own mathematical ability. Self-efficacy, or the perception of one's ability to succeed in a given situation, is an important contributor to academic success, and girls' beliefs about mathematical ability predict their later achievement (Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006).


https://mds.marshall.edu/adsp/vol13/iss1/4
DOI: -

Oddly, self-efficacy in math and math grades were found to be more weakly correlated in female students than in male students (Dickhauser & Meyer, 2006). That is, boys' beliefs about math ability are related to their actual school performance in math, but, for girls, belief and grades are not strongly related, so a girl may perform well in school but still believe she is unskilled.

One specific study provides a vivid example of the way this process can play out in a classroom, as boys and girls pay careful attention to their teachers' estimations of their mathematical ability—which is not the same thing as their actual mathematical ability (Dickhauser & Meyer, 2006). In this study, teachers rated the mathematical ability of their male students higher than the ability of their female students, despite the fact that the boys and girls scored equally, on average, in objective tests of math skill. These erroneous teacher beliefs were clearly perceived by the children: Boys rated their perceived teacher evaluations of their own mathematical ability higher than did girls. Boys also were more likely to attribute their successes in math to high ability and less likely to attribute failure to low ability than were girls; girls tended to let the teacher evaluations overrule even good objective performance.

Thus, girls who rely on perceived teacher evaluations as a measure of their mathematical ability rather than other objective measures of their performance may be more likely to underestimate their own ability. In turn, this underestimation of ability may be detrimental to future performance, because judgment of one's own ability has been found to be correlated with achievement (Muzzatti & Agnoli, 2007).

Tiedemann (2000) found that the effects of teacher expectations were amplified by parental beliefs. Mothers and fathers, on average, believed that boys were more competent in mathematics than were girls; the children's teachers also perceived boys to have more ability in math than girls, despite the fact that there were no significant differences between the boys' and girls' previous or current grades. Mothers' and teachers' beliefs about the children's ability were strongly correlated, and both of these sets of beliefs were correlated with the student's gender. Mothers' and teachers' ability beliefs had a strong influence on the child's own ability perceptions. A girl's perceptions about her mathematical ability were thus influenced by factors that had nothing to do with her ability, shaping her views about possibilities for her in mathematics because of her gender. Much like teachers, in most cases, the messages that mothers convey are a product of their own socialization transmitted unconsciously—not a deliberate choice to discourage their daughters.

Similar patterns hold for parental expectations about science. Several studies have investigated parental attitudes about their elementary-school-age children and have found that parents believe that sons are more interested in science than daughters (Tenenbaum & Leaper, 2003), have higher expectations of boys' performance than girls' (Andre, Whigham, Hendrickson, & Chambers, 1999), believe that science is more difficult and less important for girls than for boys (Andre et al., 1999; Tenenbaum & Leaper, 2003), and engage in more complex dialogue about scientific concepts with boys than with girls (Tenenbaum & Leaper, 2003). Mothers' beliefs about their children's science ability are correlated with the child's self-efficacy in science (Andre et al., 1999). One link between parental and child attitudes may be activities, which at the elementary-school age require parental endorsement. Elementary-school-age boys reported more outside activities related to science than did girls (Jones, Howe, & Rua, 2000) and reported higher self-efficacy in science than girls (Tenenbaum & Leaper, 2003).

### Peer Influence

Adults are not the only source of influence on a child's attitudes toward science and math. Peer attitudes also play a role in how positively a child feels toward these fields. Not surprisingly, children whose peers encourage positive attitudes toward science and those who have positive interactions with peers related to science have more positive attitudes (Stake, 2006) and stronger expectations that a future career in science is possible (Stake & Nickens, 2005). These findings hold for both girls and boys.

Gender plays a role in peer attitudes toward math and science, particularly as girls move from childhood to adolescence. Girls whose friends conveyed support for math and science pursuits, along with girls with gender-egalitarian beliefs, were more motivated to pursue STEM topics than those whose friends endorsed gender-typical roles (Leaper, Farkas, & Brown, 2011). The relationship between peer attitudes toward science and individual attitudes toward science grows stronger through the middle school years and peaks in strength as children enter high school (Talton & Simpson, 1985).

### Media Influence

Portrayals of science and math in the media have the potential to influence girls' attitudes and performance in STEM fields through the direct representation of science as a masculine endeavor. The degree to which this message can be detected varies according to the intended audience of the programming.

Scientists as characters in popular media have a fairly narrow and specific profile. They are male, wear a lab coat and glasses, have unruly hair, and work alone, perhaps because of deficient social skills (Steinke et al., 2007). Whereas scientists in programs targeted at children may behave in non-gender-typed ways more often than in the general media, male scientists still far outnumber female scientists in these programs (Long, Steinke, & Applegate, 2010). Even in programs specifically designed to reduce gender stereotypes and increase interest in science—some of which have shown promising results (e.g., Mares, Cantor, & Steinbach, 1999)—one study found that latent gender stereotypes remained in these well-intentioned programs (Long, Boiarsky, & Thayer, 2001).


https://mds.marshall.edu/adsp/vol13/iss1/4
DOI: -

Overall, as girls and boys move through childhood and into adolescence, it is fair to say that they have received numerous and persistent messages about the appropriateness of STEM as an area of interest. Most of those messages were never intentionally sent.

## ADOLESCENCE

Adolescence is a time of identity search, a period in which individuals actively seek to define who they are. Adolescents' habits of mind play a prominent role in their attitudes toward STEM fields, although parental and societal pressures do not disappear.

### Fixed Versus Growth Mindset

Students' beliefs about the nature of intelligence and academic ability become defined and crystallized in adolescence (Blackwell, Trzesniewski, & Dweck, 2007). The notion that academic ability is a fixed characteristic that a person either has or does not have is called a *fixed mindset*. A fixed mindset is contrasted with a *growth mindset,* the view that academic ability is a fluid skill that develops with time and practice (Dweck, 2007). When students hold a fixed mindset about their abilities, they experience decreased confidence and effectiveness when faced with an academic challenge; this pattern appears to be especially true of high academic performers. People who hold the fixed mindset call their abilities into question because they believe confusion in a subject indicates a lack of "natural" ability. They believe, for example, that if they possessed a natural gift for math, all the concepts that are introduced in their math classes would be understood without difficulty. In contrast, students who hold a growth mindset about mathematical ability are motivated by challenges, persist in the face of difficulty, and view confusion about a concept as something that can be overcome with effort.

It is encouraging to note that a growth mindset of intelligence can be taught to students, according to Blackwell et al. (2007). A group of 99 seventh graders were randomly assigned to eight half-hour workshops that taught academically at-risk students the physiology of the brain, ways to improve study skills, and how to avoid stereotypical thinking. In addition to this material, the experimental group learned that intelligence was malleable and that the brain, like any other muscle, "grows stronger" with practice, whereas the control group focused on how memory works. The researchers found that 27% of the students in the experimental group demonstrated positive change in their school work, as opposed to 9% of the students in the control group. The typical downward trend that is observed in students' grades upon entering junior high was halted for the students in the experimental group, but not for the students in the control group. The students who had originally held a fixed mindset of intelligence at the beginning of the experiment were then placed in the experimental group and experienced a reversal in their downward grade trajectory. That is, students who came into the study believing that the first sign of difficulty with math meant that they were not "math people" came instead to learn that they could succeed at math with practice, and this change in belief caused their actual performance in math to change. These findings indicate that holding a growth mindset of intelligence can halt the decline in decreased math performance in middle school students, and that a growth mindset of intelligence can be taught to students.

### Explicit and Implicit Gender Stereotypes

Adolescents hold gender-related stereotypes about STEM. For instance, children in elementary school have been found to identify science-related jobs as masculine (Andre et al., 1999). Boys as young as 7 years old report the belief that male students are better at math than female students, whereas girls say that male and female students are equally good at math until the girls are about 10 years old, when they start reporting that male students are superior in math (Muzzatti & Agnoli, 2007). During adolescence, boys adopt a more egalitarian stance, at least in their explicit statements, agreeing with the idea that boys and girls are equally good at math. Girls continue to endorse the belief of male superiority in math.

The shift in boys' attitudes may be more a reflection of what they believe is socially acceptable than a real change in belief. People may hold implicit (unconscious) beliefs shaped by societal stereotypes that contradict explicit beliefs about equality that are socially acceptable (Devine, 1989). Given the pervasiveness of the stereotype that women are incapable of math and science, it is no surprise that researchers have found evidence of this stereotype at an implicit level among both boys and girls (e.g., Steffens & Jelenec, 2011). Even though these beliefs are held outside of conscious awareness, they predict real and important outcomes, including female students' academic self-concept, performance on math exams, enrollment in future math courses, and desire to pursue a math-related career (Kiefer & Sekaquaptewa, 2007b; Steffens, Jelenec, & Noack, 2010). Thus, although we might consider the increasingly positive explicit messages that girls are equally as capable as boys at math to be a mark of progress, such explicit statements are only part of the picture. Deeply ingrained negative attitudes remain intact for many and can cause real decrements in performance.

### Stereotype Threat

*Stereotype threat* is the name for a decrease in performance that occurs when in-group stereotypes are made salient. It has been studied extensively with regard to women in STEM fields. The general finding (Spencer, Steele, & Quinn, 1999) is that when women with equally strong backgrounds and ability as men are put into a testing situation and told that the test is diagnostic of their ability


https://mds.marshall.edu/adsp/vol13/iss1/4
DOI: -

and potential in the field, the women perform worse than the men and worse than expected given their training. However, when the stereotype (women = bad at STEM) is removed—for example, by telling the women that the test is gender-neutral—women's scores equal men's scores. In other words, it is not only the content of the test that influences women's performance, but also the burden of knowing that they are representing a group that is expected to do poorly. Ironically, the more motivated a person is to do well on the test, the more interference she experiences from stereotype threat.

Stereotype threat affects girls' math performance as early as the middle-school years (Muzzatti & Agnoli, 2007). Adolescents of both genders experience a decrease in self-confidence in math after entering middle school, but the overall self-confidence of girls ends up lower because it started from a lower point. Eighth-grade students tended to rate math as being more difficult, reported expending less effort in math, and liked math less than students in lower grades. In Muzzatti and Agnoli's (2007) experiment, boys and girls in fifth and eighth grade engaged in a task that served as a reminder of the historical male majority in mathematics. Only the eighth-grade girls experienced decreased mathematical performance after the stereotype threat was initiated in this way. This finding suggests that the stereotype that males are superior in math has been internalized by this age.

Stereotype threat can worsen the effects of negative implicit attitudes, as described by Kiefer and Sekaquaptewa (2007a). Women with the strongest implicit stereotypes about women's inability to do math were affected the least by situational cues designed to reduce the stereotype threat. Women who had relatively egalitarian beliefs about math ability were found to be more influenced by the belief that a test is or is not gender fair; their test scores were more reactive to the stereotype threat than were the scores of those who already believed, at an unconscious level, that others expected them to fail.

Ironically, the stereotype threat can be elicited by very subtle cues that are common to the environment. Steele (1997) found that checking a box that indicated one's gender on a standardized test induced the stereotype threat and reduced the test scores of the most motivated, most hopeful female math students. However, even cues further removed from an academic context can induce the stereotype threat. In one study (Davies, Spencer, & Steele, 2005), ads that showed women rhapsodizing over a delicious brownie mix or contemplating some cosmetic solution to flaws in their appearance reduced women's aspirations for technical occupations, their willingness to take on leadership roles, and the number of math problems they would attempt in a mock testing situation; the gender-typed ads did not have any effect on male viewers.

### Parental Expectations for Careers

Although adolescents' own beliefs about their capabilities are very important to their academic choices and performance, parents' beliefs continue to play a role at this age. Perhaps contrary to parents' intuition about their impact, the beliefs that they hold about their children's capabilities have a noticeable effect on what their children do.

For example, mothers' gender beliefs and the corresponding expectations they have for their adolescent children strongly predict those children's careers in young adulthood (Chhin, Bleeker, & Jacobs, 2008). Specifically, mothers' expectations about whether their male and female children should have gender-traditional careers are significantly correlated with their children's gendered career expectations. Mothers' gendered career expectations for their daughters (at age 17) also significantly predict their daughters' actual gender-type career at the age of 28 years old.

One particularly important finding relates to the concept of self-efficacy. Bleeker and Jacobs (2004) found that parents directly and indirectly affected the self-efficacy of girls in STEM fields, and the mothers' influence was found to be particularly strong. Adolescent girls' STEM career self-efficacy was significantly correlated with the expectations of the mothers for their children's success. Overall, the mothers of seventh-grade girls reported lower expectations of their daughters' capacity for success in STEM fields than did the mothers of boys. These effects persisted beyond adolescence; mothers' predictions of their seventh-grade children's success in STEM fields were correlated with their adult children's STEM career self-efficacy. If mothers predicted the possibility of success for their seventh grader in a STEM career, they were more likely to have children who reported high STEM self-efficacy at the age of 20 years old.

How strong is this effect of parental expectations? Female adolescents whose mothers did not predict high success in STEM fields were 66% more likely to select a non-STEM field than a physical science field compared with those whose mothers had more optimistic attitudes. However, mothers' perceptions had only a small effect on male adolescents' selection of non-STEM careers (Bleeker & Jacobs, 2004).

By the time adolescence is over, the differences in self-efficacy are substantial between men and women, just at the time that they are making choices about entering careers. Men's STEM self-efficacy at the age of 19–20 years old is significantly higher than that of women (Chhin et al., 2008).

## ADULTHOOD

As women enter college and choose careers, the STEM gap is readily apparent. Women choose STEM majors far less often than men, and those women who graduate with STEM majors are less likely to work in STEM fields than are their male counterparts. Among the reasons that this is unfortunate is that the wage gap in STEM fields is significantly smaller than in non-STEM fields. But, the whole of society bears the cost when talented women opt out of these careers; the U.S. Department of Commerce (2011) has described this pattern as "a gender gap to innovation."


https://mds.marshall.edu/adsp/vol13/iss1/4
DOI: -

In a job setting, women in STEM fields face particular challenges that may impede their progress, reduce their satisfaction, and ultimately reduce the number of female role models available to the next generation.

### Prevention Focus

Women who enter STEM majors and careers may be prone to prevention focus as a result of the stereotype threat (Förster, Higgins, & Strack, 2000). When people work to achieve a goal, such as succeeding in a STEM field, they tend to either engage in promotional behaviors that focus on accomplishments and on moving forward, or on preventative behaviors that focus on safety and avoiding loss (Higgins, 2000). Promotional behaviors include taking reasonable risks, negotiating raises or promotions, and volunteering for projects, whereas preventative behaviors include ensuring that projects are completed on time, dressing appropriately for work, and minimizing work absences. Although both foci can lead to acceptable behaviors, promotion focus is exemplified by people who rise to the top of their chosen field or who show innovation and creativity.

Because the stereotype threat highlights the possibility that a person is likely to be judged harshly and as representative of her group if she fails, it can induce prevention focus. And, although a person who spends a lot of time focused on preventing aversive events may have the kind of success characterized by avoiding major problems, she is likely to accomplish substantially less than a person with a promotion focus and will be less likely to be in a position to hire and mentor others.

The stereotype threat most intensely affects women who are highly motivated to succeed in a gender-incongruent domain, which may cause them to engage in preventative behaviors in the workplace. People who approach their career goals with a prevention focus fail to take even appropriate risks, for their goal is to minimize potential losses and setbacks. Women with a prevention focus may also be diverting the cognitive capacity needed for complex, theoretical calculations by instead closely monitoring their behaviors to avoid conforming to gender stereotypes. Ironically, such resource diversion can cause their performance to suffer, as predicted by the stereotypes.

### Warmth Versus Competence

One of the challenges facing adult women in STEM fields has to do with perceptions of warmth and competence, two major factors that influence how humans perceive and react to others (Fiske, Cuddy, & Glick, 2006). People who are perceived to be high in both competence and warmth tend to be both well-liked and well-respected. People high in competence but low in warmth tend to be respected, but are often disliked, especially if they are considered to be in competition for resources. People low in competence but high in warmth tend to be liked, but not respected. They may be pitied or patronized by others.

Women in traditionally female fields are typically considered high in warmth but low in competence; for instance, people have very warm feelings about kindergarten teachers, but do not often recognize them as highly competent professionals (Fiske, Cuddy, Glick, & Xu, 2002). Women in STEM fields, which are considered to be male domains, especially struggle to be perceived as being as competent as their male coworkers (AAUW, 2010). However, when female workers are demonstrably competent in their work in a gender-incongruent domain, their perceived warmth plummets (Heilman et al., 2004). Successful women in male-dominated career fields are often considered uncivil, cold, and "bitchy." Being disliked in the workplace can result in missed job opportunities, promotions, or pay increases. This phenomenon results in a double bind for women: To the degree that these shifting criteria operate in her workplace, a female worker who is considered friendly may be passed over for a promotion because a male coworker is perceived to be better at the job, but a female worker who is clearly skilled at her job may be passed over for a promotion because she is considered unfit for a position that requires interpersonal skills. (Note: Because the purpose of this article is to examine barriers that are specific to STEM fields, we omit a discussion of general discrimination in the workplace. This omission is not intended to convey that we do not think these forces are a significant problem for working women, in STEM and other occupations, only that a review of the problem exceeds the scope of this article.)

### Social Norms and Attitudes

Even the criteria used for promotion in a job setting can be influenced by the candidates' gender. According to the role congruity theory of prejudice, people see leadership as being incongruous with the female gender role (Eagly & Karau, 2002; see also Diekman & Eagly, 2008). There are two consequences of this set of beliefs. One is that female candidates for a leadership role are viewed less favorably than male candidates. The other is that if certain behavior is required by a leadership role—for instance, giving direction or selecting team members—the same behavior is viewed less favorably when it is performed by a woman than when it is performed by a man.

These attitudes are pronounced when women are assessed in nontraditional fields. For example, when asked to compare the qualifications of a male and female candidate for traditionally masculine jobs (e.g., manager of a construction company, police chief), reviewers felt that experience was more important only when the male candidate had more experience than the female candidate. When the female candidate had more experience than the male candidate, experience was not important to the reviewers. When the male candidate had more education than the female candidate, education was the major factor to be considered. When the male candidate had more professional experience, professional experience was the major factor. In short, whatever assets the female candidate had going for her in her application became nonsignificant to the people making the decision. None


https://mds.marshall.edu/adsp/vol13/iss1/4
DOI: -

of the participants in these studies (Norton, Vandello, & Darley, 2004; Uhlmann & Cohen, 2005) were aware that they were influenced by gender. And, the people in the studies who discriminated the most were the ones most convinced of their own objectivity.

Role congruity can cause people to shift standards to favor male over female employees without knowing that they are doing so. In one study (Phelan, Moss-Racusin, & Rudman, 2008), participants were asked to evaluate videotaped interviews of a male or female applicant for the position of computer laboratory manager. The applicants were actors working from a script; both the male and female actors taped one interview in which they represented an "agentic," take-charge, top-down management style, and another in which they had a "communal," cooperative management style. The study participants watched one of the four interviews and rated the competence and social skills of the applicant, as well as how important competence and social skills were to the job. The agentic male manager was viewed as the most desirable candidate for the job, more so than the female who had said exactly the same things in the interview. Also, for three of the four candidates, competence was rated as more important than social skills; the only person for whom this pattern was reversed was the agentic and highly competent female manager. She alone was found to be faulty for not having skills that were unimportant for the agentic male or the communal male or female. Given that women who apply for jobs in many subfields of STEM are working against the social stereotype that these are traditionally male jobs, subtle and unconscious discrimination may limit the entry of well-qualified women into the fields or inhibit their career progress.

## Goal Affordance

People do not choose careers in isolation from social context. One important factor in the choice of careers is the degree to which people believe the careers will fulfill important social goals. Two clusters of goals can be identified by the terms *agentic* and *communal*, as described above. There are gender-based patterns in agentic and communal goal preferences in American society, but it is important not to overstate the gender differences based on stereotype.

Traditional gender roles emphasize the importance of agentic goals, such as making money, as important for men, and communal goals, such as helping others, as important for women (e.g., Abele & Wojciszke, 2007). These gender roles reflect the positions of men and women within the social structure and shape the goals that become most important to them (Diekman, Brown, Johnston, & Clark, 2010; Eagly, Wood, & Diekman, 2000). Thus, although women and men both endorse agentic and communal goals to some extent, and although women have shown increasing tendencies toward agentic goals in the recent past, there remains a gender gap in career goals, with women being more likely than men to see communal goals as important (Costa, Terracciano, & McCrae, 2001; Schwartz & Rubel, 2005).



 

Researchers who pursue this line of inquiry argue that it is important to understand the "communion gap" for two reasons. One is that STEM fields are perceived by men and women as being particularly unsuited to serving communal goals (Diekman et al., 2010). The stronger a person's commitment is to communal goals, the less interest they have in STEM careers, regardless of past experience or self-efficacy. The other is that many intervention programs designed to increase women's participation in STEM focus on agentic, rather than communal, attributes, such as self-efficacy (Diekman, Clark, Johnston, Brown, & Steinberg, 2011). Increases in women's agentic goals may have something to do with their rapid progress in previously male-dominated fields, such as medicine and law, but if women view communal goals as important and do not perceive that STEM careers will afford a chance to meet those goals, then the interventions may be limited in their success.

Fortunately, perceptions of goal affordances can be shifted, sometimes by very subtle changes. For example, changing the physical environment of a computer science laboratory so that objects and posters in the laboratory were gender-neutral increased women's sense of belonging and interest in the field (Cheryan, Plaut, Davies, & Steele, 2009). Changing an advertisement for a STEM conference to reflect gender-balanced images resulted in greater interest in attendance from women and men (Murphy, Steele, & Gross, 2007). Reading a description of a scientist's day when the activities clearly mentioned collaboration increased the participants' belief that a science career would fulfill communal goals and increased women's positivity toward science careers (Diekman et al., 2011).

As with all statements of gender differences, it is important to recognize that there is substantial overlap between men and women, so to frame the issue of agency versus communion as a direct function of gender is to seriously overstate the case. Many men endorse some degree of communal goals; some men endorse them highly, and those men also find STEM careers less attractive than their low-communion peers (Diekman et al., 2011). Given that STEM careers provide a strong opportunity to contribute to the good of society, reducing the stereotype of scientists as maladjusted loners may help increase the talent pool overall.

### Overinterpretation of Neuroscience Findings

One of the challenges facing people who attempt to find ways to increase women's participation in STEM fields is that neuroimaging has lent a veneer of credibility to age-old gender stereotypes. These days, if a person wishes to argue that there is a "female brain" that is qualitatively distinct from a "male brain" in its ability to operate in the world, that person can show pictures of brain scans to support his or her point. In a society where women are frequently steered away from math and science through overt and subtle discouragement, there are some "experts" in the popular press who nonetheless believe that young women opt away from STEM fields only because of immutable biological differences.


https://mds.marshall.edu/adsp/vol13/iss1/4
DOI: -

The problems with using neuroscience in this way are manifold. The most obvious problem is that some of the best-known findings in the popular press are made up or are grossly overgeneralized (Fine, 2010). Another is that brain functions change with time and experience (e.g., Doidge, 2007) so that, even if men and women show differences in patterns of activations, those differences may be reflective of their environments and are therefore subject to change. The matter of interpretation is also problematic; people who are not trained in neurosciences may believe that if they see an area of the brain lit up on a scan, they are seeing actual thought or emotion or even capability. What they are really seeing are things like blood oxygenation or glucose metabolism, and the link between these activities in a particular brain region and specific thoughts, feelings, and behavior is not as strong as many assume. (Note: Dartmouth neuroscientist Craig Bennett made this point by performing a functional magnetic resonance imaging scan on a [dead] Atlantic salmon while asking the fish to engage in an emotion-decoding task by identifying the emotions being experienced by people in photographs. The scanner detected some brain activation in the dead fish. Had the fish been [a] alive and [b] human, the tendency would be strong to believe that it had been thinking about the photos [Bennett, Baird, Miller, & Wolford, 2010].)

The most cutting-edge science of any era, whether it was the balance of vital humors in the body, phrenology, or prenatal testosterone exposure, has been used to justify social stereotypes. The scientific language changes, but the conclusion—women are unsuited by nature for any fields that they do not currently occupy—remains the same. And this language matters; women who hear evidence about supposedly hard-wired differences in mathematical ability perform more poorly on math tasks than those who do not receive such messages (Dar-Nimrod & Heine, 2006). Thus, declaring sex differences in STEM ability can create sex differences in STEM ability, but not because of biologically determined ability levels.

It is true that there are observable physical differences between men and women, in their brain structure and activity and in the rest of their physiology. However, it is a mistake to conclude that such differences are the sole or major reason for women's lack of participation in STEM fields, particularly given all the demonstrable effects of gender-stereotyped socialization. That is, although differences in physiology exist, to write off gender differences in STEM participation as an inevitable consequence of biology can be used as an excuse to justify the status quo and can allow members of society to avoid taking action to address social factors that are also significant influences on career choice.

## CONCLUSION

In 2010, Mattel—with the assistance of the Society of Women Engineers and the National Academy of Engineering—released Computer Engineer Barbie

(Miller, 2010). The Barbie sports a pink laptop, a Bluetooth headset, and a neon green shirt featuring pink binary numbers. Voters selected her career from a list of possible options that included computer engineer, architect, environmentalist, news anchor, and surgeon. Mattel and its fans provided an opportunity for Barbie to enter a career path that has traditionally been considered a male domain. It is time for parents, educators, and employers to do the same for women and girls.

Increasing the number of women in STEM fields not only benefits women, but also society as a whole. Having more women in STEM careers would decrease the gender wage gap in society, because STEM jobs for women pay approximately 33% more, on average, than non-STEM jobs for women. Although there remains a gender wage gap within STEM, it is smaller than for other areas (U.S. Department of Commerce, 2011). Female scientists would help diversify the topics examined in scientific fields, resulting in new research that benefits the community. In addition, having a highly skilled workforce, including math and science competence, is important for a society's economic development. If the basic standard of living in a society is tied to that society's productivity, and STEM is a particularly productive field, then society should encourage all of its members to participate to the fullest extent of their abilities.

Parents, educators, and employers can begin to untangle the effects of expectations on girls' and women's performance by identifying the factors that contribute to the ongoing underrepresentation of women in STEM and by making the corresponding modifications in behavior. Freed from these negative expectations, girls and women can use their abilities to lead more productive lives, to their benefit and to the benefit of society as a whole.

## REFERENCES


Abele, A. E., & Wojciszke, B. (2007). Agency and communion from the perspective of self versus others. *Journal of Personality and Social Psychology, 93,* 751–763.

American Association of University Women. (2010). *Why so few? Women in science, technology, engineering, and mathematics.* Washington, DC: Author.

Andre, T., Whigham, M., Hendrickson, A., & Chambers, S. (1999). Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects. *Journal of Research in Science Teaching, 36,* 719–747.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences, 107,* 1860–1863.

Bennett, C. M., Baird, A. A., Miller, M. B., & Wolford, G. L. (2010) Neural correlates of interspecies perspective taking in the post-mortem Atlantic salmon: An argument for multiple comparisons correction. *Journal of Serendipitous and Unexpected Results, 1,* 1–5.

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development, 78,* 246–263.

Bleeker, M. M., & Jacobs, J. E. (2004). Achievement in math and science: Do mothers' beliefs matter 12 years later? *Journal of Educational Psychology, 96,* 97–109.

Cheryan, S., Plaut, V. C., Davies, P., & Steele, C. M. (2009). Ambient belonging: How stereotypical environments impact gender participation in computer science. *Journal of Personality and Social Psychology, 97,* 1045–1060.

Chhin, C. S., Bleeker, M. M., & Jacobs, J. E. (2008). Gender-typed occupational choices: The long-term impact of parents' beliefs and expectations. In H. M. Watt & J. S. Eccles (Eds.), *Gender and occupational outcomes: Longitudinal assessments of individual, social, and cultural influences* (pp. 215–234). Washington, DC: American Psychological Association.

Costa, P. T., Jr., Terracciano, A., & McCrae, R. R. (2001). Gender differences in personality traits across cultures: Robust and surprising findings. *Journal of Personality and Social Psychology, 81,* 322–331.

Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science, 12,* 258–261.

Crowley, K., & Siegler, R. S. (1999). Explanation and generalization in young children's strategy learning. *Child Development, 70,* 304–316.

Dar-Nimrod, I., & Heine, S. J. (2006, October 20). Exposure to scientific theories affects women's math performance. *Science, 314,* 435.

Davies, P. G., Spencer, S. J., & Steele, C. M. (2005). Clearing the air: Identity safety moderates the effects of stereotype threat on women's leadership aspirations. *Journal of Personality and Social Psychology, 88,* 276–287.

Devine, P. G. (1989). Stereotypes and prejudice: Their automatic and controlled components. *Journal of Personality and Social Psychology, 56,* 5–18.

Dickhauser, O., & Meyer, U. (2006). Gender differences in young children's math ability attributions. *Psychological Science, 48,* 3–16.

Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2010). Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science, 21,* 1051–1057.

Diekman, A. B., Clark, E. K., Johnston, A. M., Brown, E. R., & Steinberg, M. (2011). Malleability in communal goals and beliefs influences attraction to STEM careers: Evidence for a goal congruity perspective. *Journal of Personality and Social Psychology, 101,* 902–918.

Diekman, A. B., & Eagly, A. H. (2008). Of men, women, and motivation: A role congruity account. In J. Y. Shah & W. L. Gardner (Eds.), *Handbook of motivation science* (pp. 434–447). New York, NY: Guilford.

Doidge, N. (2007). *The brain that changes itself: Stories of personal triumph from the frontiers of brain science*. New York, NY: Viking.

Dweck, C. S. (2007). Is math a gift? Beliefs that put females at risk. In S. J. Ceci & W. M. Williams (Eds.), *Why aren't more women in science? Top researchers debate the evidence* (pp. 47–55). Washington, DC: American Psychological Association.

Eagly, A. H., & Karau, S. J. (2002). Role congruity theory of prejudice toward female leaders. *Psychological Review, 109,* 573–598.

Eagly, A. H., Wood, W., & Diekman, A. B. (2000). Social role theory of sex differences and similarities: A current appraisal. In T. Eckes & H. M. Trautner (Eds.), *The developmental social psychology of gender* (pp. 123–174). Mahwah, NJ: Erlbaum.

Fine, C. (2010). *Delusions of gender: How our minds, society, and neurosexism create difference.* New York, NY: Norton.

Fiske, S. T., Cuddy, A. J. C., & Glick, P. (2006). Universal dimensions of social cognition: Warmth and competence. *Trends in Cognitive Sciences, 11,* 77–83.

Fiske, S. T., Cuddy, A. J. C., Glick, P., & Xu, J. (2002). A model of (often mixed) stereotype content: Competence and warmth respectively follow from perceived status and competition. *Journal of Personality and Social Psychology, 82,* 878–902.

Förster, J., Higgins, E. T., & Strack, F. (2000). When stereotype disconfirmation is a personal threat: How prejudice and prevention focus moderate incongruency effects. *Social Cognition, 18,* 178–197.

Friese, M., Hofmann, W., & Schmitt, M. (2008). When and why do implicit measures predict behaviour? Empirical evidence for the moderating role of opportunity, motivation, and process reliance. *European Review of Social Psychology, 19,* 285–338.

Heilman, M. E., Wallen, A. S., Fuchs, D., & Tamkins, M. M. (2004). Penalties for success: Reaction to women who succeed in male gender-typed tasks. *Journal of Applied Psychology, 89,* 416–427.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21,* 33–46.

Higgins, E. (2000). Beyond pleasure and pain. In E. Higgins, A. W. Kruglanski, E. Higgins, & A. W. Kruglanski (Eds.), *Motivational science: Social and personality perspectives* (pp. 231–255). New York, NY: Psychology Press.

Jones, M., Howe, A., & Rua, M. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. *Science Education, 84,* 180–192.

Kenney-Benson, G. A., Pomerantz, E. M., Ryan, A. M., & Patrick, H. (2006). Sex differences in math performance: The role of children's approach to schoolwork. *Developmental Psychology, 42,* 11–26.
Kiefer, A. K., & Sekaquaptewa, D. (2007a). Implicit stereotypes and women's math performance: How implicit gender-math stereotypes influence women's susceptibility to stereotype threat. *Journal of Experimental Social Psychology, 43,* 825–832.
Kiefer, A. K., & Sekaquaptewa, D. (2007b). Implicit stereotypes, gender identification, and math-related outcomes: A prospective study of female college students. *Psychological Science, 18,* 13–18.
Leaper, C., Farkas, T., & Brown, C. S. (2011). Adolescent girls' experiences and gender-related beliefs in relation to their motivation in math/science and English. *Journal of Youth and Adolescence, 41,* 268–282.
Lee, V. E., & Burkam, D. (2002). *Inequality at the starting gate: Social background differences in achievement as children begin school*. Washington, DC: Economic Policy Institute.
Levine, S. C., Suriyakham, L., Rowe, M. L., Huttenlocher, J., & Gunderson, E. A. (2010). What counts in the development of young children's number knowledge? *Developmental Psychology, 46,* 1309–1319.
Long, M., Boiarsky, G., & Thayer, G. (2001). Gender and racial counter-stereotypes in science education television: A content analysis. *Public Understanding of Science, 10,* 255–269.
Long, M., Steinke, J., & Applegate, B. (2010). Portrayals of male and female scientists in television programs popular among middle school-age children. *Science Communication, 32,* 356–382.
Malzahn, K. A. (2002). *Status of elementary school mathematics teaching.* Chapel Hill, NC: Horizon Research.
Mares, M., Cantor, J., & Steinbach, J. B. (1999). Using television to foster children's interest in science. *Science Communication, 20,* 283–297.
Mattel says it erred; Teen Talk Barbie turns silent on math. (1992, October 21). *The New York Times*. Retrieved from http://www.newyorktimes.com
Miller, C. C. (2010, February 12). Barbie's next career? Computer engineer. *The New York Times*. Retrieved from http://www. newyorktimes.com
Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science, 18,* 879–885.
Muzzatti, B., & Agnoli, F. (2007). Gender and mathematics: Attitudes and stereotype threat susceptibility in Italian children. *Developmental Psychology, 43,* 747–759.
Norton, M. I., Vandello, J. A., & Darley, J. M. (2004). Casuistry and social category bias. *Journal of Personality and Social Psychology, 87,* 817–831.
Perry, D. G., & Bussey, K. (1979). The social learning theory of sex differences: Imitation is alive and well. *Journal of Personality and Social Psychology, 37,* 1699–1712.
Phelan, J. E., Moss-Racusin, C. A., & Rudman, L. A. (2008). Competent yet out in the cold: Shifting criteria for hiring reflect backlash towards agentic women. *Psychology of Women Quarterly, 32,* 406–413.
Pronin, E., Steele, C. M., & Ross, L. (2003). Identity bifurcation in response to stereotype threat: Women and mathematics. *Journal of Experimental Psychology, 40,* 152–168.
Schwartz, S. H., & Rubel, T. (2005). Sex differences in value priorities: Cross-cultural and multimethod studies. *Journal of Personality and Social Psychology, 89,* 1010–1028.
Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology, 35,* 4–28.
Stake, J. E. (2006). The critical mediating role of social encouragement for science motivation and confidence among high school girls and boys. *Journal of Applied Social Psychology, 36,* 1017–1045.
Stake, J. E., & Nickens, S. D. (2005). Adolescent girls' and boys' science peer relationships and perceptions of the possible self as scientist. *Sex Roles, 52,* 1–11.
Starkey, P., Klein, A., & Wakeley, A. (2004). Enhancing young children's mathematical knowledge through a pre-kindergarten mathematics intervention. *Early Childhood Research Quarterly, 19,* 99–120.
Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52,* 613.
Steffens, M. C., & Jelenec, P. (2011). Separating implicit gender stereotypes regarding math and language: Implicit ability stereotypes are self-serving for boys and men, but not for girls and women. *Sex Roles, 64,* 324–335.
Steffens, M. C., Jelenec, P., & Noack, P. (2010). On the leaky math pipeline: Comparing implicit math-gender stereotypes and math withdrawal in female and male children and adolescents. *Journal of Educational Psychology, 102,* 947–963.
Steinke, J., Lapinski, M. K., Crocker, N., Zietsman-Thomas, A., Williams, Y., Evergreen, S. H., & Kuchibhotla, S. (2007). Assessing media influences on middle school-aged children's perceptions of women in science using the Draw-A-Scientist Test (DAST). *Science Communication, 29,* 35–64.

Talton, E. L., & Simpson, R. D. (1985). Relationships between peer and individual attitudes toward science among adolescent students. *Science Education, 69,* 19–24.
Tenenbaum, H. R., & Leaper, C. (2003). Parent–child conversations about science: The socialization of gender inequities? *Developmental Psychology, 39,* 34–47.
Tiedemann, J. (2000). Parents' gender stereotypes and teachers' beliefs as predictors of children's concept of their mathematical ability in elementary school. *Journal of Educational Psychology, 92,* 144–151.
Uhlmann, E. L., & Cohen, G. L. (2005) "I think it, therefore it's true": Effects of self-perceived objectivity on hiring discrimination. *Organizational Behavior and Human Decision Processes, 104,* 207–223.
U.S. Department of Commerce. (2011, August). *Women in STEM: A gender gap to innovation* (Issue Brief 04-11). Washington, DC: Economics and Statistics Administration, U.S. Department of Commerce.