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ABSTRACT

Researchers from economics, sociology, psychology, and other disciplines have studied the persistent under-representation of women in science, technology, engineering, and mathematics (STEM). This chapter summarizes this research. We argue that women's under-representation is concentrated in the math-intensive science fields of geosciences, engineering, economics, math/computer science and physical science. Our analysis concentrates on the environmental factors that influence ability, preferences, and the rewards for those choices. We examine how gendered stereotypes, culture, role models, competition, risk aversion, and interests contribute to gender STEM gap, starting at childhood, solidifying by middle school, and affecting women and men as they progress through school, higher education, and into the labor market. Our results are consistent with preferences and psychological explanations for the under-representation of women in math-intensive STEM fields.

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Introduction

The list of math and science greats throughout history is a list of men – Pythagoras, Hippocrates, Aristotle, Euclid, Copernicus, Galileo, Kepler, Fermat, Newton, Gauss, Faraday, Darwin, Mendel, Einstein—with a few women entering this pantheon starting in the late 19th and early 20th centuries, such as Curie and Mead (Rogers 2010). Even newer fields such as computer science and information technology as well as genomics are dominated by men—from Jobs and Gates to Sanger, Watson, and Collins. Thus, it is no surprise that people associate science, technology, engineering, and mathematics (STEM) with men (Harvard Implicit Project, Banaji and Greenwald 2013) and conclude that since the most successful scientists are men, perhaps only men can successfully pursue science.

The lack of women in STEM disciplines and occupations can have real-world implications for women and society. First, science and innovation that fails to take women into account can have long-lasting impacts. For example, women were excluded from NIH-funded clinical trials prior to 1993 and subsequent inclusion led to the discovery that women respond differently to many medications (Clayton and Collins 2014, US General Accounting Office 2001). Findings like these have given rise to a call to take sex and gender into account in science and innovation.[1] Second, STEM fields such as engineering pay higher salaries than non-STEM fields, and the lack of women in STEM may contribute to the gender salary gap (Beede et al. 2011). Finally, Hong and Page (2004) have argued that a diverse group of problem-solvers can outperform a group of the best problem-solvers. Thus, increasing gender diversity in STEM may give rise to new and improved innovations.

Over the past three decades, researchers from economics, sociology, psychology, and other disciplines have tried to understand why women are under-represented in STEM, even as this under-representation shrank. This chapter summarizes this research, focusing mostly on the US context. One key finding is that STEM fields differ: each features a different set of skills and a different labor market along with different gender representation. Increasingly, women's under-representation is limited to the math-intensive science fields—geosciences, engineering, economics, math/computer science, and physical science—which we refer to as the GEMP fields (as we did in Ceci et al. 2014). We denote other STEM fields as LPS—life sciences, psychology,

[1] For examples, see Gendered Innovations: https://genderedinnovations.stanford.edu/what-is-gendered-innovations.html.

and social sciences (excluding economics). Thus, STEM is an overly broad categorization of science and engineering fields, and here we focus on the challenges to women's progress in LPS and GEMP fields separately.

To best summarize the research on women in STEM, we start at childhood and then follow girls and boys as they progress through middle and high school, college and additional higher education, and then into the job market. At each stage, we describe overall gender differences before delving into their possible causes. We squarely address the possibility of biological differences, but concentrate on the environmental factors that have been shown to greatly affect measured ability, choices at every life stage, and the rewards and incentives for those choices. The factors include stereotyping by family, teachers, and peers; cultural roles; role models; competition and risk aversion; interests; and beliefs not directly linked to gender. The work in this area convinces us that the roots of women's STEM underrepresentation starts in childhood and, as a result, much of this chapter is devoted to these years.

STEM-Related Differences during School Years

It is generally believed that math ability and skills are necessary for STEM careers. Are girls' math abilities and skills sufficient for them to pursue those fields? If not, when do differences arise and are they affected by environmental factors?

The early years through middle school

It is extremely difficult to untangle biological ability differences from cultural effects. In Ceci et al. (2014), we summarized the literature on pre-school gender differences in spatial ability and found that infant and toddler boys perform better than girls on some spatial-rotation tests in most studies. However, even at these early ages, subtle environmental or developmental factors may influence this, such as early crawling and object manipulation.

Once children enter school, more direct measurements of math ability are available. Scores on standardized math tests such as the US National Assessment of Educational Progress (NAEP) or the Trends in International Mathematics and Science Study (TIMSS) international math test show that on average, young girls do *not* consistently perform worse in math tests than young boys and that differences in averages were very small. For instance, Hyde et al. (2008) found that in the mid-2000s in the US, boys had higher standardized average NAEP math scores in grades 2 and 3 but that girls had the advantage between in grades 4 through 9. However, no gap was larger than .06 standard deviations. Two articles find that male advantages are not present at school entry. Both Fryer and Levitt (2010) and Penner and Paret (2008) studied a nationally representative cohort of American children who entered kindergarten in 1998, and found that boys and girls enter kindergarten with similar average math test scores, but a male advantage appears by spring of first grade that increases to .15–.20 standard deviations (.23 with controls) by the end of 5th grade (covering 1998–2004). These two articles are based on very different data than Hyde et al. (2008), which was cross-sectional data based on a different test, so it is not surprising that results are not identical. Together, they point to three important qualitative facts: boys do not start school with a math-test advantage; a male advantage appears sometime during the first four grades; and average gender differences are a small fraction of a standard deviation.

There are also differences between countries during early years. For instance in 1994–95, Mullis et al. (2000), using a different test, found that 4th grade boys and girls in the US and other countries including Hong Kong, Scotland, Greece, and Canada did equally well, but in Korea and Japan girls did significantly worse.

Boys, however, have a higher variance in math scores than girls throughout early grades. This leads to more boys in both tails of the math distribution. If those who enter math-intensive STEM jobs are primarily taken from the right tail in the math ability distribution, boys' higher variance would lead to more boys than girls in STEM jobs. The higher variance is present at kindergarten entrance. For instance, Fryer and Levitt (2010) find that in the US, the ratio of boys to girls in the top 1% is 1.59 entering kindergarten, but rises to 2.34 by 5th grade. Other evidence suggests that the major gender differences in math scores in the US are concentrated only at the very top of the distribution, since boys and girls were approximately equally represented in the top quarter of math performers, although there were fewer girls than boys in the top quarter in other countries including Japan, Korea, and the Netherlands (Mullis et al. 2000).

Middle School to Secondary School

For whatever reason, the die seems cast by the end of middle school. Gender differences in average math scores stabilize somewhere around puberty/middle school, and do not later reverse. We note here some of the many studies on this topic. Hyde et al. (2008) finds that US boys' average advantage starts in grade 10 and is around .05 standard deviations. Pope and

Snydor (2010) found a similar male advantage in the same test given in a later year, but this advantage arose earlier in 8th grade. Friedman-Sokuler and Justman (2016) also find average differences of .05 standard deviations for Israeli 8th graders (using a different test). Using a different test, Stoet and Geary (2013) analyzed 1.5 million 15 year olds in 33 countries and found differences at the median of .11 standard deviations. Even the largest of these average math score differences are objectively small, and are smaller than those observed in earlier decades.[2] With such large samples, statistical significance is a given; however, there is little economic significance to these small differences.

However, the average gender gap in tests varies across countries, US states, and ethnicities. Cross-nationally, Stoet and Geary (2013) find the math difference in average scores among 15 year olds range from .25 standard deviations in South Korea and .21 in Greece to a *female* advantage of .17 in Iceland and .05 in Thailand, with the US having a .07 male advantage. Mullis et al. (2000) found that in Advanced Math Achievement, boys in the last year of high school did better than girls in all countries, but in some countries this difference was small and insignificant (on the order of 2% in Australia and Greece to 6% in the US to 16–18% in Austria and the Czech Republic).

As was true in earlier grades, substantial gender differences in math tests do exist at the top tail as children get older. The ratio of male-to-female math scores among those in the top 1% was 2.09:1 for white US 11th graders (Hyde et al. 2008), 1.17:1 for 8th graders (Pope and Snydor 2010), 2.3:1 internationally for 15 year olds (Stoet and Geary 2013) and 1.1:1 for Israeli 8th graders (Friedman-Sokuler and Justman 2016). Providing a time trend but using a different test than Hyde and Pope and Snydor, Wai et al. (2010) found that the 7th grade male-female ratio in the top 1% fell from 13.5:1 in the early 1980s to 3.9:1 in the early 1990s, but has remained fairly stable after that point.

High school is typically the first time that children have control over the subjects that they study, and on average girls are less likely to take more-advanced math and science courses. Xie and Shaumann (2003) found that in the US, girls were less likely to participate in science and engineering courses in high school. Additional evidence for this is based on the gender composition of US Advanced Placement (AP) test-takers in STEM disciplines, since taking the

[2] For example, there was .25 standard deviation gender gap in the 1972 National Longitudinal Survey (Goldin, Katz, and Kuziemko 2006).

AP test in a subject is almost always associated with taking the corresponding AP-level courses. As Table 1 shows, considerably fewer girls than boys take AP courses in math, computer science, and math-intensive sciences. More girls than boys take AP courses in biology and environmental science, two STEM disciplines that do not rely on strong mathematical skills. Table 1 also indicates that girls who take STEM AP tests score lower than boys on average in all of these STEM subjects, including biology and environmental science, and fewer girls than boys score the maximum of 5 in every subject area.

In higher education, the key outcome studied is the choice of major field. Figure 1 shows the percent female from 1994–2014 in the US among all high school degrees granted, all bachelors' degrees granted, and separated STEM bachelors granted into majors in math-intensive STEM fields (geosciences, engineering, economics, math and computer science, and physical science) compared with less-math-intensive STEM fields (life sciences, psychology, and social sciences excluding economics). We refer throughout to the first group as GEMP and the second as LPS. The distinction is important in understand gender gaps in STEM.

Figure 1 indicates that in the 2010s, around 50% of US high school degrees were granted to women, as well as 57% of all US bachelors' degrees. If we had graphed all STEM majors together, we would have seen that women also earned 57% of STEM bachelors' degrees. Instead, Figure 1 divides STEM majors into GEMP and LPS, revealing substantial differences across STEM fields. In 2014, women received only 27% of bachelors' degrees in the math-intensive GEMP fields, but 69% of bachelors' degrees in LPS fields.

If we were to follow the time trend for individual STEM fields further back in time than shown in Figure 1, we would see that the women's representation in each separate STEM field increased rapidly in the 1970s. Women's representation among psychology and life sciences majors continued to grow in the 1980s and 1990s before it stabilized, both ending above 70%. In contrast, female representation among economics majors stagnated as early as 1984 and then fell in the 2000s, while female representation in computer science fell drastically after 1984. Until the last decade when computer science replaced it, engineering had the lowest female representation, although women's representation in engineering, geosciences, and physical sciences grew considerably through around 2000. All of these patterns were very different from humanities majors, which throughout the period 1980–2014 remained between 54% and 60% female.

Fewer than 10% of US STEM undergraduate majors later graduate from a PhD program in STEM, with more men doing so than women. Figure 2 shows that the percentage of GEMP majors continuing to PhDs over the past decades grew and the gender gap in this percentage virtually disappeared. In contrast, the percentage of LPS majors continuing to PhDs fell for both genders, while its gender gap hardly changed. In light of the huge growth in LPS majors over this period (more than doubling) and limited sizes of university PhD programs, it is not surprising that the overall percent of LPS majors proceeding to a PhD has fallen. However, given the exploding number of women majors, it *is* surprising that there remains a stable female disadvantage in proceeding to a PhD. This may be due to preferences and interests, which we discuss in a separate section. Or it may be due to lower female rates of post-PhD career success, also addressed in later sections. Finally, women may choose shorter education periods that do not preclude the possibility of devoting time to children. After all, total education time, post-bachelors' degree, is shorter for those choosing masters or professional degrees like business, law, or medicine; for instance, in biomedicine, a PhD plus postdoc takes longer than an MD plus residency (Kahn and Ginther 2017).

Figure 3 shows the female representation among US-granted STEM PhDs from 1970 to 2014, divided into more narrow STEM fields. Female representation in all STEM fields showed continual growth across from 1970 until the mid-2000s, in contrast to GEMP undergraduate majors' stagnation throughout the 1990s and 2000s (Figure 1), and in contrast to humanities PhDs, which also stagnated in the 1990s and 2000s (Figure 3). The growth in female representation among psychology, life sciences, and other social sciences PhDs has been particularly large (each growing by more than 40 percentage points) although percentage-wise, the female representation grew most in engineering which started at less than 1% and rose to 23%. Female representation in all PhD fields stagnated from the Great Recession and on.

International evidence mostly shows similar patterns of female representation. This includes Barone (2011), who described majors across eight countries in 1999–2000. However, in China, women are far under-represented in most STEM majors, although they are over-represented in math and chemistry (Guo et al. 2010).

The Association between STEM Measured Ability and STEM Educational Choices

A number of factors can explain an association between math and science (STEM) test scores, STEM course-taking, and STEM college major: (a) students may choose (or be tracked into) courses and majors in the areas where they excel; (b) previous course-taking may increase math/science test scores; or (c) third factors such as inherent preferences could simultaneously lead to different courses taken different majors, and different test scores. Identifying which of these causal stories is key to this association is difficult. However, if one factor—such as preferences, test scores, course-taking—can be shown to pre-date others, this suggests a causal story. We also report on the few natural experiments that make causal interpretations more credible.

Many articles find that previous grades or test scores are correlated with subsequent choices concerning STEM course-taking and majors, but the correlation explains little of the overall gender differences in these outcomes. Moreover, whether boys or girls are most affected by past performance seems to depend on the subject. For instance, Friedman-Sokuler and Justman (2016) studied Israeli high school STEM elective course choices, controlling for 8th grade standardized test scores. Grades had a relatively small effect on the probability of choosing these STEM courses. Girls were more sensitive to grades in biology and chemistry, but boys were more sensitive in computer science and physics.

Studying different periods (1980s to the early 2000s), Xie and Shaumann (2003) and Riegle-Crumb et al. (2012) both found that US high school STEM test scores and grades were correlated with high school graduates' expectations of majoring in STEM fields in college, although this explained only a small fraction of the gender difference in STEM majors. Interestingly, Xie and Shaumann (2003) found that most STEM majors had intended in high school to major in non-science fields but switched to STEM during college. In addition, they found that female students were more likely to choose STEM majors during college.

Most other studies use data from a single university. Ost (2010) found that grades in introductory STEM courses in a large US university had a lasting effect on majoring in that subject. Grades in these courses affected women's majors more than men's in life sciences, but affected men's majors more than women's in physical sciences (similar to Friedman-Sokuler and Justman's finding); however these gender differences were not statistically significant. Rask (2010) examined data from a US liberal arts college. There, women's major choices were more sensitive to introductory course grades than men's in biology and psychology, while men's major choices were more sensitive to grades in computer science, geology, math, and physics. Stinebrinkner and Stinebrinkner (2011) combined all sciences and found that while both men and women responded to low science grades by changing their expected major from science, this change was more pronounced for men because they had gone into college overly-optimistic about their science ability.

Using data from different universities, Owen (2010) and Main and Ost (2014) both investigated introductory economics grades' impact on majoring in economics using a regression-discontinuity method at letter-grade cutoffs to more accurately identify causality.[3] Controlling for numeric grades, Owen (2010) found that girls', but not boys', major choices were affected while Main and Ost (2014) found no impact of grades for either men or women. The difference in results could be because the university Owen studied used only full letter grades, so cutoffs make a larger difference than in the university Main and Ost studied where plusses/minuses were used.

Rather than investigating whether high STEM scores affected later STEM course-taking or majors, others have investigated whether high school math-intensive STEM course-taking alone predicted later STEM college majors. In the US, Morgan et al. (2013) found it did not. However, De Phillippis (2016) exploited a natural experiment of rollouts of a UK program that increased the number of advanced science courses available to high-ability 14 year olds and found that taking more science in high school led to a higher probability that boys would later major in STEM; he found no comparable effect for girls. This might accord with Gottfried and Bozick (2016), who found that students who take courses in applied STEM areas in high school (mostly boys) were more likely to choose an applied STEM major.

If grades or scores in STEM encourage or discourage students to major or take courses in STEM, it stands to reason that these students are comparing their performance in STEM to their performance in non-STEM courses. Therefore, what matters may not be STEM ability, but STEM ability relative to other abilities. Several researchers have directly tested this. Wang et al. (2013) followed people from high school until age 33 and found that individuals with both high math and verbal ability (usually, women) were less likely to be in STEM occupations than individuals with high math but moderate verbal scores. Riegle-Crumb et al. (2013) found that the comparative advantage in STEM ability compared to verbal abilities explained more of the choice of college major than STEM ability alone. On the other hand, Friedman-Sokuler and

[3] The idea is that students with grades just above and below letter-grade cutoffs should be fairly similar in abilities, even though their grades differ more.

Justman (2016) found that Israelis who do very well in both math and verbal skills in 8th grade tests were more likely to choose STEM electives than those only who only did very well in math. They themselves note the contradiction with the previous studies and conjecture that it might be due to "different stages of education, variation over time, or cultural differences." Addressing a slightly different measure of comparative advantage, Ost (2010) found that men (only) decreased their likelihood of persisting in a physical science major if they performed better in introductory life sciences.

The Impact of Stereotypes, Ability Beliefs and Preferences on Educational Choices

Beliefs about ones' own mathematics ability rather than ability itself may influence the STEM choices we observe. Evidence of the importance of students' beliefs date back at least to 1986, when Eccles and Jacobs (1986) identified the importance of attitudes and beliefs on math performance. Notably, they found that children's estimates of their own math ability and their belief that math is valuable affects their future math performance, even after controlling for actual past performance. Eccles and Wang (2016) showed that twelfth graders self-concepts about their math ability (controlling for measures of actual math and verbal ability) increased the likelihood that 10 years later they were in a STEM career. Here we examine how gendered stereotypes about STEM throughout the life course influence STEM majors and careers.

Stereotypes in the Early Years

Boys and girls seem to learn stereotype bias in school. For instance, Cvencek, Meltzoff, and Greenwald (2011) reported that by second grade, both boys and girls had implicit and explicit stereotypes associating math with the category "males." Interestingly, by that age boys also associated *themselves* with math and girls associated *themselves* with reading.

Some evidence in the psychological literature shows that the belief that math ability is malleable and can be developed is itself self-fulfilling. This is called "growth mindset" or incremental theory. Bian et al. (2017) provides the only evidence of gender differences in growth mindsets in the early grades. Girls aged 5–7 were introduced to games in different ways, one being for "children who are really, really smart" and one for "children who try really, really hard." Boys and girls aged 5 made similar choices among these games, but by ages 6–7, girls were less interested than boys in the games for really smart children. There is more evidence that in high school, boys are much more likely to have a math growth mindset than girls. For instance, controlling for scores on standardized math tests, by 10th grade boys are .2 standard deviations more likely ($p<.001$) than girls to believe that math can be learned (Nix et al. 2015).

Researchers have found a correlation between a math growth mindset and math performance, math interest, and math course-taking in middle school and high school (e.g., Blackwell et al. 2007, Nix et al. 2015, Good et al. 2012). Many researchers found that this relationship appears around puberty/middle school and is particularly evident in challenging and difficult mathematics topics. As an example, Blackwell et al. (2007) found a correlation of growth mindset with standardized math grades in 7th grade, but not in 6th grade. In some cases, the link between growth mindset and math scores exists for girls but not boys, or is larger for girls (e.g., Nix et al. 2015, Dweck 2006).

Yet simple interventions have been shown to make a difference on growth mindsets, at least in the short run. Two very similar experiments were performed on middle school students, where the treatment was tutoring that emphasized a math growth mindset compared to tutoring without this emphasis (Blackwell et al. 2007; Good, Aronson, and Inzlicht 2003.) In both studies, girls who learned with a growth mindset performed equally well (or insignificantly better) than boys with the same treatment, compared to the control group, where boys did much better than girls. Even minor interventions had short-run effects. An experiment found that when a high schooler (whom the authors argue was seen as a role-model) told 6th graders before a math test that students' success was due to effort exerted, scores increased for girls but not boys: girls with this intervention scored 5% higher than boys, but without this intervention scored 20% lower (Bages et al. 2016).

Family's Contributions to Math Gender Stereotypes

Gender differences in math achievement may be transmitted across generations. Eccles and Jacob (1986) and Eccles, Jacob, and Harold (1990) found that mothers' gendered stereotypes about math ability influenced their perceptions of their children's abilities. If mothers held gendered stereotypes, their rating of their daughter's ability was lower than would have been predicted by the teacher's evaluation of ability. In particular, Eccles and Jacob (1986) found that mother's beliefs had a greater influence on children taking additional math courses than their children's actual performance. They conclude that, "These data suggest that parents' gendered stereotype beliefs are a key cause of sex differences in students' attitudes toward mathematics." (Eccles and Jacob 1986, 375).

Results in Xie and Shaumann (2003) suggest that parental expectations contribute to the gender gap in math tests. They compared the estimated effect of gender in two regressions of high (top 5%) 12th grade math achievement, one including only individual characteristics as explanatory variables and the other adding in controls for parental expectations of a student's educational attainment, parental education, family income and the family computer-ownership. Since average family characteristics besides expectations are similar for boys and girls, any change in the gender effect was likely due to differences in expectations. They found that family expectations were responsible for a .05 difference in the female/male high math achievement ratio. However, parental expectations had no influence on gender differences in the probability of selecting a STEM college major. Overall, they concluded that family only explains a small part of the gender gap in STEM achievement.

Parents' math anxiety predicts children's lower math achievement when these parents helped their children with homework (Maloney et al. 2015). Moreover, Eccles and Jacob (1986) found that mothers felt that math was more difficult for their daughters than for their sons, and that mothers' beliefs about their children's difficulty in math was strongly related to their children's math anxiety.

Fryer and Levitt (2010), who identified a gender math gap increasing between kindergarten and 5th grade, found this increase was greatest among those whose mothers had a bachelor's degree or higher.[4] Parents had lower math expectations for girls than boys, but—similar to Xie and Shaumann—they found that controlling for parental expectations hardly changes the gender math gap.

The growth mindset of parents is also associated with children's performance in mathematics and STEM. Cheng, Koptic, and Zamorro (2017) found that parents' math growth-mindset increased children's growth mindset with the effect on girls twice as large as on boys. Having a parent employed in a STEM occupation increased a child's probability of majoring in and working in STEM, and the effect was larger for girls (between 10–17 percentage points). In addition, girls with mothers employed in STEM were 7 percentage points more likely to be employed in the "hard sciences" (GEMP). They concluded that maternal role-modeling and growth mindsets can help close the gender gap.

[4] Whether the mother was in a math occupation or whether she had more education than the father did not affect the gender math gap.

Teachers' Contributions to Math Gender Stereotypes

Do teachers' math gender stereotypes affect girls' beliefs and math performance? In the 1970s, numerous case studies found that teachers spent more time teaching boys math—both formally and informally—than they spent on girls in the early grades (e.g., Leinhardt et al. 1979, Astin 1974). This alone can have profound permanent changes in children, given the recent literature on how sophisticated mathematical education for young children that emphasizes "fluid cognitive skills" permanently changes the neurobiology of the prefrontal cortex (Blair et al. 2005).

More recent literature has directly related teachers' math stereotypes to outcomes. Beilock et al. (2009) found that US first- and second-grade girls who had female teachers with math anxiety were more likely than girls with female teachers without math anxiety to believe at year's end that "boys are good at math and girls good at reading" and to have lower math achievement. Using a differences-in-differences methodology, Lavy and Sand (2015) measured teacher gender bias in early grades in Israel by comparing scores on tests graded by teachers and machine-graded standardized tests, in both math and English. They found that girls with elementary and middle school teachers who were biased against girls in math ultimately took fewer high school math courses and were less likely to major in STEM fields and have STEM occupations. Cornwell, Mustard, and Van Parys (2013) applied this approach to US data and found that bias against boys could be explained by boys' behavior and non-cognitive skills: boys with better behavior received higher grades. Nevertheless, it appears that stereotypes have solidified into adolescent girls' poor assessment of their math abilities relative to boys, controlling for one's standardized math scores.

Interestingly, in a similar case of teacher-graded compared with standardized test scores at the high school matriculation level (with teacher random assignment) Lavy (2008) found evidence of bias against boys in Israel in all subjects. According to Lavy and Sand (2015), this reverse bias occurred too late to make a difference in math course-taking during high school.

Culture and Math Gender Stereotypes

Cultural differences stereotypes may also affect math stereotypes and hence achievement. Guiso et al. (2008) analyzed the association between math scores and gender-equality indices for students in 40 countries. They found that the gender gap in mathematics disappears in gender-equal countries, while girls' advantage in reading scores widens, the more gender-equal the country. Using results on a standardized test from 9 different countries, Nollenberger, Rodriguez-Planas, and Sevilla (2016) examined math scores of second-generation immigrants who may be influenced by the cultural attitudes of their parents, as measured by their home countries' gender-equality measures, and/or the institutions of their new homes. They find that two-thirds of the gender math gap can be explained by parents' cultural attitudes. Nosek et al. (2009) collected data on the implicit association test (IAT) of gendered stereotypes about science from nearly 300,000 individuals from 34 countries in 2003. They discovered that the gender gap in math and science in the 8^{th} grade increased with the country's level of gendered science-stereotyping. This result remained even after controlling for the country's gender-equality measures.

Pope and Sydnor (2010) found related results for the US. They showed that states with more boys among the highest achievers in math and science tests also had more girls among highest achievers in reading. Further, interstate differences in stereotypical attitudes about women working outside the home and in children's agreement with the statement "math is for boys" are highly correlated with gender differences in math-science compared to reading scores. These facts suggest the role of culture.

One study—Fryer and Levitt (2010)—arrived at the opposite conclusion. In pooled 4^{th} and 8^{th} grade exams, they find that a countries' gender equality index does not affect the gender gap in test scores, although Islamic countries have less of a gender gap, perhaps because they have single-sex classrooms. Given the wide variety of tests showing the opposite for older children, we suspect that this contrary result may be dominated by the younger group.

Taken together, this literature shows that the more equal the society or the less prevalent a gendered stereotype for math and science, the better girls' STEM achievement.

Role models and Math Gender Stereotypes

In the US, the lack of role models at all levels of STEM education reinforces the dearth of women in STEM. Economists have examined the association and used the random assignment of teachers to examine the effect of instructor gender on student math outcomes and choices, with differing results. Antecol et al. (2015) found that primary school girls randomly assigned to teachers got better math scores if taught by women rather than men, but only when the women teachers had strong math backgrounds; girls got lower scores if taught by women teachers with weak math backgrounds. Ehrenberg, Goldhaber, and Brewer (1995) found no same-gender teacher effects on improvement in math and science test scores. However, in responses to survey questions, they found that female teachers gave better subjective evaluations to female students than male teachers gave to female students. In contrast, Dee (2005, 2007) found that same-gender teachers enhanced the achievement of both male and female 8th graders in all subjects. Finally, Winters et al. (2013) found that same-sex teachers did *not* improve achievement of either gender in elementary school. However, in middle and high school, both genders benefited more from a female teacher, although there was less of an impact for boys in math classes. These three studies' differing results may depend on context. Moreover, in none of these last three studies could the researchers be certain that teacher assignment was random (although generally they assumed it was), which may have contributed to different findings.

All studies at the college level of same-gender teachers have found positive effects on women. Most inferred the direction of causation from the random assignment of instructors. For instance, Bottia et al. (2015) showed that exposure to female STEM teachers in high school (where random assignment to teachers is more likely) increased the probability that female students major in STEM in college, especially for girls with high math ability, but did not have an effect on male students' majors. Several other studies only examine the correlation between instructor gender and STEM majors. These found that once in college, female students are more likely to pursue STEM majors if they have had female faculty (Canes and Rosen 2005, Rask and Bailey 2002). Qian and Zafar (2009) calculated that exposure to female faculty increased the number of female students later majoring in engineering but not other STEM fields. Griffith (2010) found that women were less likely to major in STEM fields at research-intensive institutions, but this effect was moderated if there were more female graduate students.

Three other studies identified the causal effect of instructor gender by examining outcomes from first-year courses where assignment to faculty was random. Hoffman and Oreopoulos (2009) found that students taught by a same-sex instructor had better grades, but this was driven by males performing worse when they had a female instructor. They also found that having a same-sex instructor decreased the probability of dropping a course. Carrell, Page, and West (2010) found that the highest-ability women were more likely to pursue a STEM major and achieved better grades if assigned to a female STEM instructor. Griffith (2014) found that female instructors increased female students' grades in courses in male-dominated disciplines such as STEM, but found no effect of on women's decisions to pursue a major in those fields.

Finally, two articles used instruments to identify causal effects of instructor gender. Bettinger and Long (2005) used the fraction of courses in a field taught by female instructors at the university as an instrument for the potentially endogenous female-instructor variable,[5] and found that exposure to female faculty increased the likelihood of majoring in mathematics and geology. However, Price (2010) constructed an instrument from the aggregate STEM/non-STEM percentage of female faculty and found that female students were less likely to persist in STEM courses if they were taught by a female instructor.

Competition and Math Gender Stereotypes

Elsewhere in this Handbook, we learn that girls and women perform less well than boys and men in competitive environments and that this is particularly true when it comes to competing against boys and men (Shurchkov and Eckel). Here we review the literature as it relates to STEM courses and majors as well as single-sex schools. Cotton, McIntyre, and Price (2013) conducted a series of math competitions in elementary schools. They found that boys outperformed girls in the first test, but girls outperformed boys on subsequent tests. In addition, girls performed just as well as boys on the first test when time pressure was removed. Niederle and Vesterlund (2010) have suggested that girls' lower math test scores may be a response to competition. In particular, they argue that math test scores are biased downwards for girls relative to their mathematical skills because of the competitive nature of math test-taking. Also, girls are sensitive to the gender of their competitors, and since more boys pursue mathematics, this lowers girls' math scores. In addition, Niederle and Yestrumkas (2008) found that female Stanford undergraduates shy away from difficult tasks, compared to men. To the extent that STEM courses are considered "difficult," this gender difference may also be driving choices of major. Finally, in France, Landaud, Ly, and Maurin (2016) found that girls in more-competitive high schools were less likely to study math and science. Orrenius and Zavodny (2015) found that share of college-aged immigrants in a state reduced the percentage of women majoring in science and engineering. They attribute this to cohort crowding in these majors. Taken together, these results suggest that competitive pressure seems to adversely influence girls' performance in mathematics.

[5] The number of courses taught by female instructors depends upon the number of female instructors in the field employed by the university, which is correlated with having a female instructor but exogenous to the decision to major in STEM.

Risk-aversion is related to competition, and Baldiga (2013) found that women answered significantly fewer questions than men when the wrong answer was penalized, but not when there was no penalty. Although these test questions were not related to math and science, Baldiga's results suggest that risk-aversion may also be contributing to the gender gap in test scores.

Confidence may contribute to the observed gender gap in choosing to compete. Kamas and Preston (2012) show that gender differences in the probability of college students entering a winner-take-all math tournament was completely explained by the students' expected ranking in the competition, which the authors call confidence. However, there were no gender differences in the choice to enter the tournament for students majoring in STEM disciplines even before controlling for confidence. This suggests that women in STEM majors in their sample do not shy away from competition.

Do same-sex schools affect girls' performance, in light of the observation that girls do not like to compete against boys? Doris et al. (2013) studied this issue in Irish primary schools where single-gender public schools are common, arguing that this is close to a natural experiment: schools being single-sex was due to "historical accident" and most children attended the closest school. They found a significant gender gap in math achievement in favor of boys, but no evidence that single-sex schools reduced the gap and weak evidence that, instead, there are larger gender differentials for children educated in single-sex schools. Park, Behrman, and Choi (2012) exploit random assignment of students into single-sex schools in Seoul, South Korea. They found large effects of single-sex schools for boys' math test scores, interest in STEM, and subsequent pursuit of STEM majors. However, while single-sex schools increased girls' college entrance math exam scores, they did not affect girls' interest in STEM majors. Thus, single-sex schools do not appear to influence girls' participation in STEM.

Gender differences in STEM Preferences and Interest

Even at early ages, boys and girls show different preferences and interests towards different subjects, including different subjects within STEM. These preferences have been found to be extremely important in determining educational and occupational choices (e.g., Eccles and Jacobs 1986). In fact, a survey by Zafar (2013) found that the single largest factor determining college majors for both genders was whether they enjoyed the coursework; the second largest factor for women was whether they believed that they will enjoy working at the jobs available with that major. Wiswall and Zafar (2015) added an experimental component to this analysis by randomly providing some students information about the earnings and employment of people who chose that major. They continued to find that preferences are the dominant factor in major choice, although they also find that the naïve analyses correlating beliefs and gender overestimated the impact of preferences because preferences are correlated with expected earnings. Xie and Shaumann (2003) attribute the large gender gap in STEM representation that they cannot explain to preferences. But what is the source of different preferences?

Xie and Shaumann argue that preferences are influenced by gendered norms. Others take a different approach by examining the psychology of gendered job preferences. In our earlier survey (Ceci et al. 2014), we summarized some of the psychology literature on gender preferences. This literature finds that on average women are more people-oriented and men more thing-oriented, and that this dichotomy explains both vocational preferences and college majors (e.g., Lippa 1998, 2001, 2010; Su, Rounds, and Armstrong 2009; Baronne 2011). More recently, Eccles and Wang (2016) found that gender differences between entering GEMP or LPS occupations were best predicted by women's greater preferences for work that was altruistic and that was people-oriented, compared with men's preferences for thing-oriented work. Women's people-oriented preferences may explain why women prefer biological and psychological science, and relative to men are more likely to choose medicine instead of a doctorate in biology.

A recent addition to the topic of gender differentiation of job preferences in the economics literature emphasizes skills. Lordan and Pischke (2016) divided job attributes into people, brains and brawn (identified through factor analysis) and measured how job satisfaction by gender reflects these attributes. Along a similar vein, Baker and Cornelson (2016) divided job skills into sensory (vision, hearing, touch), motor and spatial, and then measure how occupational choices reflect these skills.[6] Interestingly, Lordan and Pischke (2016) found women like both their brain-oriented and people-oriented jobs. Weinberg (2000) and Beaudry and Lewis (2014) found that one reason for falling female-male wage differentials is due to women being good at jobs requiring brains (rather than brawn).

Taken together, this research suggests that preferences may be an important reason for some of the under-representation of women in STEM and for their different choices within STEM.

[6] However, sensory skills are quite different from the people-oriented dimension in the psychology literature.

Women in STEM Occupations

Occupational choice is also reviewed elsewhere in this Handbook (Pan and Cortes). In this section, we describe gender differences between the kind of occupations held by women and men who received bachelors' degrees in STEM.[7] We use the NSF's 2013 National Survey of College Graduates (NSCG) and its definitions of STEM disciplines and jobs. In the NSCG, only 36% of women with a bachelor's degree or higher in a STEM field actually worked full-time in STEM jobs or in management jobs directly supervising scientists. An additional 14% worked in health-related jobs and 5.7% worked in K-12 education, which is likely to be science-related. This totals 56%, but even this may undercount those involved in science; some may be higher-level managers of science enterprises, science journalists, etc.[8]

Table 2 shows the broad occupations of those with STEM bachelor's degrees who are working full-time, by major field and gender.[9] In all of these STEM majors, women are more likely than men to work in education and in health-related jobs. Men are more likely than women to work in computer, technology, and engineering jobs and in management and business jobs.

Engineering majors have the greatest gender similarity in distributions across occupations. In fact, the ratio of the proportion of women to men in engineering occupations is quite close to 1 (.87) for engineering majors, but much smaller for other majors (.14). In other words, those women who chose engineering majors look in many ways like men who chose engineering. Male and female economics majors also have a quite similar distribution across occupations. However, men and women with physical science and computer science majors hold quite different types of jobs ($p<.001$), as Table 2 shows.

In our work on engineering (Ginther and Kahn forthcoming) we have found that occupational categories can be a poor proxy for whether an individual is using their STEM degree in their work. Instead, we rely on the NSCG survey that asks "how related is your job to your highest degree?" Using this question, we find that, overall, 82.2% of men and 80.5% of women ($P<.001$) with highest degrees in STEM indicate that their job is closely or somewhat related to their highest degree, a much higher percentage than are working in the narrow occupation "science." Figure 4 breaks this down by field of highest degree. Men and women are

[7] We choose to do this rather than by focusing only on women with STEM doctorates, or even more specifically on those in academia (see Ceci et al. (2014) for a comprehensive review). Less than 10% of STEM majors proceed to PhDs and a mere 1.2% of all STEM majors are in academic jobs in colleges and universities.

[8] NSF separates out direct supervisors of scientists, but not higher-level management.

[9] We discuss part-time workers below.

practically identical in the probability their jobs are related to their STEM major fields. With the exception of computer science, none of the gender differences are significant. Ginther and Rosenbloom (2015) show that women were less likely than men to start in computer science jobs after completing their degree and significantly more likely to leave those jobs.

Gender and Earnings in STEM Jobs

According to Blau and Kahn (2016), in the overall labor market in the mid-2010s, the female-to-male ratio of average hourly earnings for US full-time workers was 79% to 82% (depending on the data set)—an improvement compared to 62%–63% in 1980. However, the ratio for elite women and men—defined as those in the 90th salary percentile—currently stands at 74%. A significant portion of the gender salary gap disappears after control for occupation (and the corresponding time flexibility), work hours, and other characteristics of the jobs. Does a similar wage/salary gender gap exist for STEM jobs?

The literature on salary gaps in STEM is relatively thin, and much of it refers to specific fields or to academia only. The US Commerce Department analyzed gender differences in STEM employment and earnings. They defined STEM as excluding psychology or any social sciences. They found that the gender salary gap was narrower in STEM than in non-STEM occupations (14% v. 21%), which also implies that the STEM-non-STEM salary gap is larger for women than men (62% v. 48%) (Beede et al. 2011). Graham and Smith (2005) looked at 1993 earnings in STEM jobs held by bachelor's degree or more-educated workers and found an overall gender earnings gap of 16%. They explained two-thirds of that gap, with the most important explanatory variables being job sector (government, industry, self-employed, etc.), whether the person was a supervisor, the level of degree, and years of experience. People educated in math-intensive (GEMP) fields particularly earned more, as demonstrated for 1985 college graduates by Weinberger (1999), and more recently by Beede et al. (2011).

The literature on academia is larger, but still not extensive. Kelly and Grant (2012) found an earnings gap among faculty of 20% in both STEM and non-STEM faculty salaries. The annual report of the American Association of University Professors repeatedly identifies gender salary gaps, but does not control for variables such as age or field that give rise to these gaps.[10]

Other work finds female salary disadvantages in academia within specific disciplines.

[10] For the latest survey, see https://www.aaup.org/our-programs/research/faculty-compensation-survey/2016-2017-faculty-compensation-survey.

Ceci et al. (2014) calculates 2010 STEM gender salary gaps by academic rank. Most fields and the lower academic ranks had no significant salary gaps, but there were significant salary gaps of about 13.5% among assistant professors in both life sciences and in economics. Among full professors, economics had the largest gender salary gap (26%), while full professors in other GEMP fields except math had gaps between 11–17%. In life sciences research-oriented jobs, Dunning (2012) found no, or a small, significant gender gap among many academic jobs, but larger ones among others, including lab managers, assistant professors, and research associates. Earnings gaps in academic medicine is the topic of Freund et al. (2016) and several earlier studies referenced there, all of whom found gender gaps. In Freund et al. (2016), the gap was 7.6%, controlling for experience, academic rank, department, work activities, family status, and past leaves.

To add to this literature, for this article we analyzed gender wage gaps among a much larger group—all persons with a bachelor's degree or higher, whose highest degree is in STEM or STEM-related fields. Our data come from the 2013 NSCG and our findings. Our sample includes only employees working more than 35 hours per week and making more than minimum wage. With no controls, there was a 28% overall gender salary gap. This is larger than the overall gap identified earlier by Graham and Smith (2005), although it is similar to the gap Blau and Kahn (2016) found among the elite men and women noted above.

By controlling for field, age, race, level of highest degree, Carnegie-rating of first bachelor's degree (a measure of university quality), marital status, and presence of children, we halved this gap to 14.6%. Field of study was an important control, particularly because of the paucity of women with engineering and computer science degrees, the highest-paying STEM fields. In a second regression, we included all of these controls but allowed family variables (marriage, children) to affect men and women differently. We found that among those never-married without children, the unexplained gender gap falls to 5.3% *ceteris paribus* but is still highly significant. However, among those currently married with children, even with all background controls, the gap is 28.2%. In other words, family characteristics have a huge effect on the gender earnings gap.

In a third regression, in addition to the background controls and gender-specific family variables, we also added in variables about the person's current job and work-time, including weekly hours, weeks worked annually, employment sector, years worked at current job, and whether the person was working 3 years previously. In this specification, never-married women without children actually made more than never-married men without children (5.4% more, $p<.01$). We conclude that for childless, never-married men and women in identical fields and sectors and with controls for other relevant characteristics, women seem to even earn more than similar men.

In this third regression, the earnings gap for married men and women with children also falls when job characteristics are added, to 12.4%—less than half of the 28.2% it had been without job variables. Thus job sector and job characteristics are a major reason for the earnings difference between married men and women with children. Of the job variables, employment sector has the most explanatory power: substantially fewer women are in the highest-paying non-academic private sector and substantially more are in the lower-paying education sector.

In Kahn and Ginther (2017b), we performed a similar gender salary gap analysis limited to STEM PhD-holders. There, we found a smaller overall salary gap of 17%. However, some of the patterns are similar to our results described above for the STEM bachelors' degree or above population, particularly the key importance of job sector and field. To a lesser extent, age was also important for PhDs, since men with STEM PhDs tend to be older than women, because women are more recent additions to the stock of STEM PhDs.

In our analysis, as well as Graham and Smith's (2005), considerable gender pay differences resulted from STEM women and men being in different fields and different employment sectors. Family also creates a wedge in salaries: married men receive a large marriage premium while married women with children experience a penalty (as in the general labor market, Juhn and McCue 2017).[11] Of course, one's plans for family can also affect one's choice of field and particularly job sector, possibly magnifying the effects of having a family.

Avoiding or Leaving STEM Occupations: The role of family, hours, and preferences

The labor force participation of US women peaked in 2000 at 60%, stabilized around 59% through 2009, and has since dropped to 57% percent. This decrease has given rise to the narrative of "opting out" in the popular press (Belkin 2003). The opting-out narrative highlights the conflicts between work and family confronted by professional women who are often

[11] A male marriage premium of about 30 log points compared to single men is observed in the overall labor market and this has been roughly constant over time. The female marriage penalty is much more of a motherhood penalty that has fallen to between 1.3 and 4.1 log points (Juhn and McCue 2017).

partnered with professional men. Here we show that this narrative applies to many women in STEM careers.

We frame this discussion using Coser's concept of "greedy institutions": those organizations that demand one's full attention and reduce time spent on competing activities (Coser 1974). Goldin and her coauthors have argued that many professional occupations such as MBAs and lawyers are "greedy occupations" that demand significant face time, and in the case of law, billable hours (Goldin 2014; Goldin and Katz 2011; Bertrand, Goldin, and Katz 2010). Cortes and Pan (2016) found that women were less likely to choose occupations with high work hours. Goldin (2014) and Goldin and Katz (2016) found that women were attracted to occupations such as veterinary medicine and pharmacy, where hours were predictable.

Long work hours also come into conflict with the demands of raising a family, which is considered another of Coser's greedy institutions. In the case of MBAs, the gender earnings gap grew over time and was associated with presence of children and limited flexibility in hours of work. MBAs who were mothers worked fewer hours, shifted to less demanding jobs, or left the labor force entirely (Bertrand, Goldin, and Katz 2010). If women do leave the labor force after the birth of their first child, Hotchkiss, Pitts, and Walker (2014) found that they experience an earnings penalty of about 51% and that penalty is higher for women with a college education. Thus, the hours demanded by "greedy occupations" and the conflict between work and family are associated with leaving the labor market or substantial earnings penalties. Is this also the case with STEM occupations?

A small literature addresses these issues as it relates to gender and science careers. Xie and Shaumann (2003) found that married women with children are less likely to complete their STEM degree, to pursue a STEM career, to participate in the labor force, to be promoted in a STEM job, and to move to better jobs. Preston (1994, 2004) found that in the 1980s and 1990s, women were more likely to leave science because of work-life balance issues and lack of mentoring. Glass et al. (2013) compared women in STEM careers to those in non-STEM professions. Although they found few differences between women in STEM and non-STEM professions in terms of hours, job satisfaction and job flexibility, women in STEM do not persist in these jobs and instead move into non-STEM and non-management jobs. They argue that the "climate" in STEM occupations explains women's propensity to leave. Our own work has captured family's impact on women leaving engineering and computer science occupations.

Kahn and Ginther (2015) found that a lack of part-time work available in engineering was associated with women leaving engineering occupations. For those with bachelors' degrees in engineering, we found that the gender retention gap is due to women leaving the labor market entirely, and it is highly correlated with child-bearing. Moreover, the likelihood of women leaving the labor market is lower in engineering than in other majors, and lower for single childless women than for men.

Ginther and Rosenbloom (2015) examined gender differences in leaving computer science occupations. Conditional on having a computer science degree, women are significantly less likely than men to work in computer science occupations. This gap was associated with the presence of young children, that is, once women had children, they were significantly more likely to leave these occupations. Once they control for the share of immigrants in the computer science major, they found that women were less likely to work in computer science occupations. This result was also found by Orrenius and Zavodny (2015) for all science and engineering fields.

There is also some evidence of chilly climates—uncomfortable work environments for women—due to the under-representation of women in STEM. For instance, Hunt (2016) found that women are more likely to leave jobs that are heavily male and that this by itself explains the difference in exit rates of women from STEM and non-STEM. Hunt's results dovetail with Lordan and Pischke's (2016) finding that women are less satisfied in occupations with lower shares of females, although controlling for the attributes of the occupation lowers the size of this relationship by more than a third. Moreover, this results persists if they control for the share of males in the firm, suggesting that work environments with more men are indeed "chilly climates." These are attributes of all male-dominated jobs, not just STEM jobs. Finally, Kahn and Ginther (2015) find that the higher propensity to leave engineering is limited to those with children or about to have children, suggesting the chilly climate may be manifest in less time flexibility or similar child-friendly workplace accommodations.

Taken together, the time commitments demanded by work and raising a family affect women's probability of pursuing STEM careers and their persistence in those careers. In addition, the "climate" in STEM occupations, proxied by the share of men in those occupations, decreases women's job satisfaction and is correlated with the likelihood that they leave.

Conclusion

Why are there fewer women in STEM disciplines and what can be done about it? We started this essay by grappling with the very notion of STEM as it relates to gender, arguing that it is a very general catch-all that masks important gender differences in science and engineering fields. We prefer the taxonomy of LPS (life science, psychology, and social sciences excluding economics) and GEMP (geoscience, economics, engineering, math and computer science, and physical science), where LPS and GEMP are differentiated by mathematical requirements. We traced the contentious literature on gender differences in mathematical ability and performance. Arguments for early biological differences are not conclusive and do not affect ability at kindergarten entrance. The literature is converging on a consensus that there are only small gender differences in mathematics tests scores at early ages, but the gender gap widens by middle and high school. In addition, more boys perform in both tails of the mathematics distribution with significantly more in the right tail than girls. To the extent that those who study STEM are drawn from the right tail of the math ability distribution, this may give rise to some of the gender differences we observe in STEM.

Nevertheless, a growing body of literature in economics and other social sciences has found that gender differences in mathematics test scores are mutable and can be influenced by family, teachers, culture, stereotypes, and role models throughout the schooling process. Teachers and to a lesser extent family are important contributors to gendered stereotypes and can have a negative influence on girls' mathematics performance. Role models and gender equality in a given culture can decrease the gender gap in mathematics performance. The competitive nature of test-taking may understate girls' true mathematical abilities. Changing the "growth mindset" belief that success in mathematics requires effort can improve girls' performance.

Women's lower representation in STEM can first be observed in high school. Girls take more STEM courses and Advanced Placement exams, but these are mostly in less math-intensive areas. Once in college, women's representation among both LPS and GEMP majors grew until the 2000s but then stopped growing, and for GEMP has fallen since. Similarly, women as a percentage of doctorates awarded in LPS plateaued in 2006 and in GEMP in 2010. This is not a picture of women's continual progress in STEM disciplines.

Our results are consistent with preferences and psychological explanations. Women prefer people-centered, altruistic, non-competitive jobs with women colleagues. This not only affects the decision to major in STEM, but also to pick LPS fields, as well as jobs such as medical doctor instead of research scientist.

Family considerations are also important since they affect the decision of job sector (e.g., fewer STEM women working in industry, more in health and education), whether to work in a job related to one's STEM degree, or even whether to work at all. STEM fields influence earnings, with salaries in GEMP being higher than those in LPS. We demonstrate that controlling for field, job sector, hours and weeks worked, job tenure, whether the person was employed in the previous three years, and employment sector erases the entire salary gap between men and women with children.

Women are less likely to pursue and more likely to leave jobs where long hours leave less time for family considerations. In addition, recent literature shows that a "chilly climate" measured by the share of men working in that occupation is associated with less job satisfaction and an increased likelihood of leaving STEM fields such as engineering. To the extent that STEM and especially GEMP fields are male-dominated, this may lead to a self-fulfilling prophecy of few women in these fields and give rise to the stagnation of women's share in STEM majors and careers that we have observed.

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Tables and Figures

Table 1: Gender Differences in selected U.S. STEM Advanced Placement Test-Taking, 2016.

	% of those taking S&E AP Exam			Average Scores		% With Highest Score	
Subject Area	% of Males	% of Females	%Female	Males	Females	Males	Females
Biology	13.6%	23.5%	60.9%	3.01	2.73	9.0%	4.8%
Calculus AB	22.8%	24.5%	49.2%	3.03	2.84	26.7%	21.7%
Calculus BC	10.5%	8.5%	42.1%	3.91	3.68	51.9%	43.8%
Chemistry	11.3%	12.3%	49.6%	3.05	2.90	21.3%	17.8%
Computer Science A	6.5%	2.2%	23.3%	2.83	2.45	12.9%	6.4%
Environmental Science	9.7%	13.3%	55.2%	2.75	2.38	9.7%	5.8%
Physics 1 & 2	17.5%	12.3%	38.8%	2.49	1.99	5.6%	1.8%
Physics C (Electricity)	2.6%	0.9%	24.6%	3.50	3.26	34.5%	24.7%
Physics C (Mechanics)	5.6%	2.4%	27.8%	3.66	3.24	33.8%	21.1%
Total	100.0%	100.0%	47.4%	3.04	2.73	20.7%	14.3%

Source: The College Board.

Table 2: Distribution of U.S. STEM Employment Across Occupations by College Major and Gender, 2013

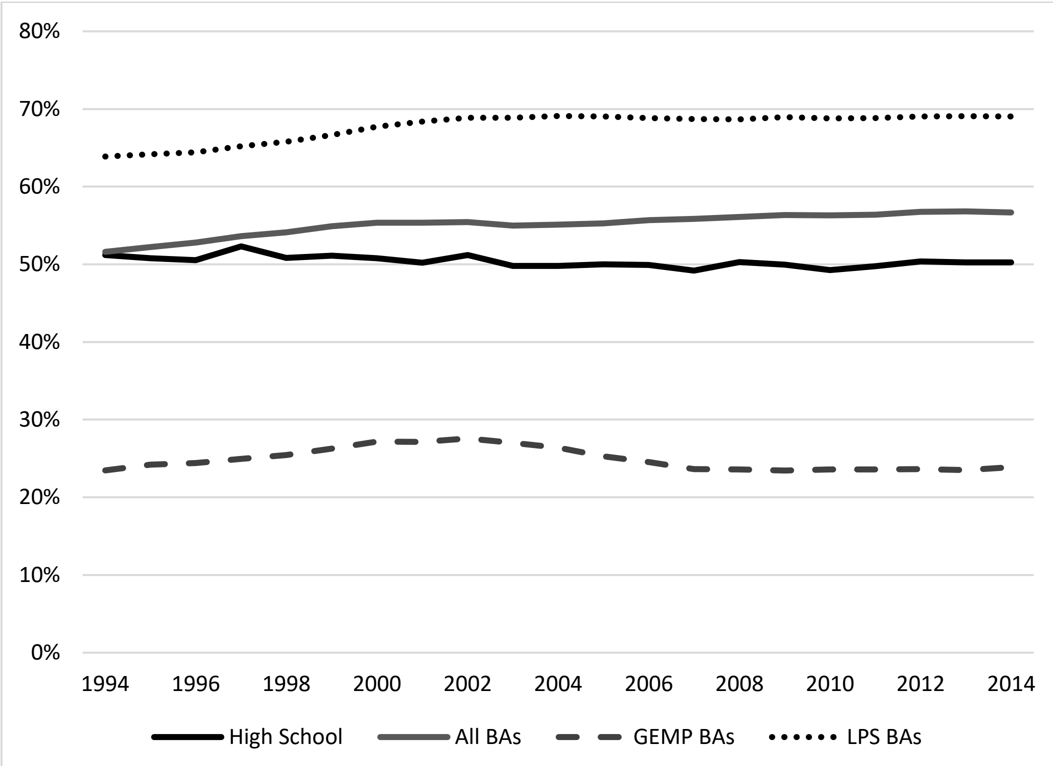
	College Major									
Employment Sector	Computers & Technology, Phys. Sci.		Life Science and Psychology		Engineering		Economics		Other Social Sci	
Occupation	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Science	11.6	13.0	13.5	11.4	2.3	3.9	3.6	5.2	4.8	4.1
Engineering	11.2	3.9	2.6	0.6	48.4	42.3	2.7	0.9	2.4	0.3
Health	5.2	6.9	28.7	36.3	1.5	4.8	2.3	7.4	7.3	15.6
Computers	36.8	23.9	3.7	1.8	15.8	13.4	5.5	2.5	4.4	2.0
Management/Business	19.2	20.5	24.9	19.8	21.7	22.6	58.8	51.0	36.8	28.8
Education	3.8	14.3	4.8	11.1	1.1	4.1	2.8	7.0	7.6	13.7
Other Professional	3.0	4.3	5.3	4.4	1.5	2.9	10.3	7.0	18.5	15.0
Other	9.3	13.2	16.4	14.7	7.7	6.0	14.1	19.1	18.3	20.6
All	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Occupational categories:

- Science: Includes jobs categorized by NSF as science or (directly) managing scientists, including social sciences (except for psychology), excluding computer science and engineering.
- Engineering: Includes jobs categorized by NSF as engineering, engineering-related, or managing engineers.
- Health: Includes all medical/health professionals and semi-professionals and psychologists, counselors and social workers.
- Computers: Includes jobs categorized as the NSF as computer science or computer programming, or managing computer systems.
- Management/Business: Excludes those categorized by NSF as those directly managing scientists.
- Education: All those teaching K-12 or teaching non-S&E subjects in tertiary education.
- Other Professional: Non-STEM, non-business professions including law, arts, clergy, etc.
- Other: All other jobs including clerical, skilled and unskilled manual, and service occupations.

Source: NSCG 2013. Includes only those working full time.

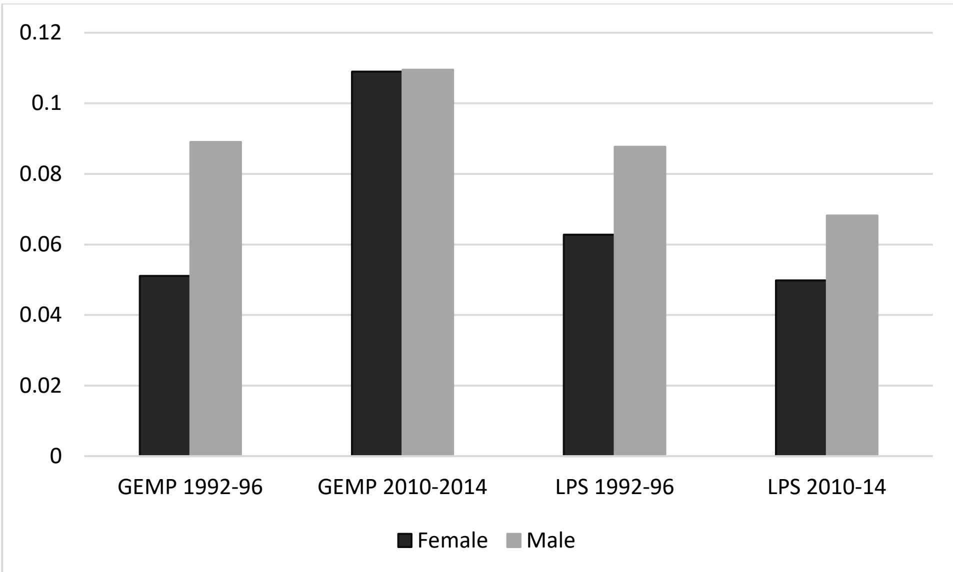
Figure 1: Percentage Female among All US High School and College Graduates and by STEM Field, 1994–2014



STEM majors divided into two categories:
GEMP (math-intensive) fields: geosciences, engineering, economics, math and computer science, and physical science.
LPS (less-math-intensive) fields: life sciences, psychology, and social sciences excluding economics.

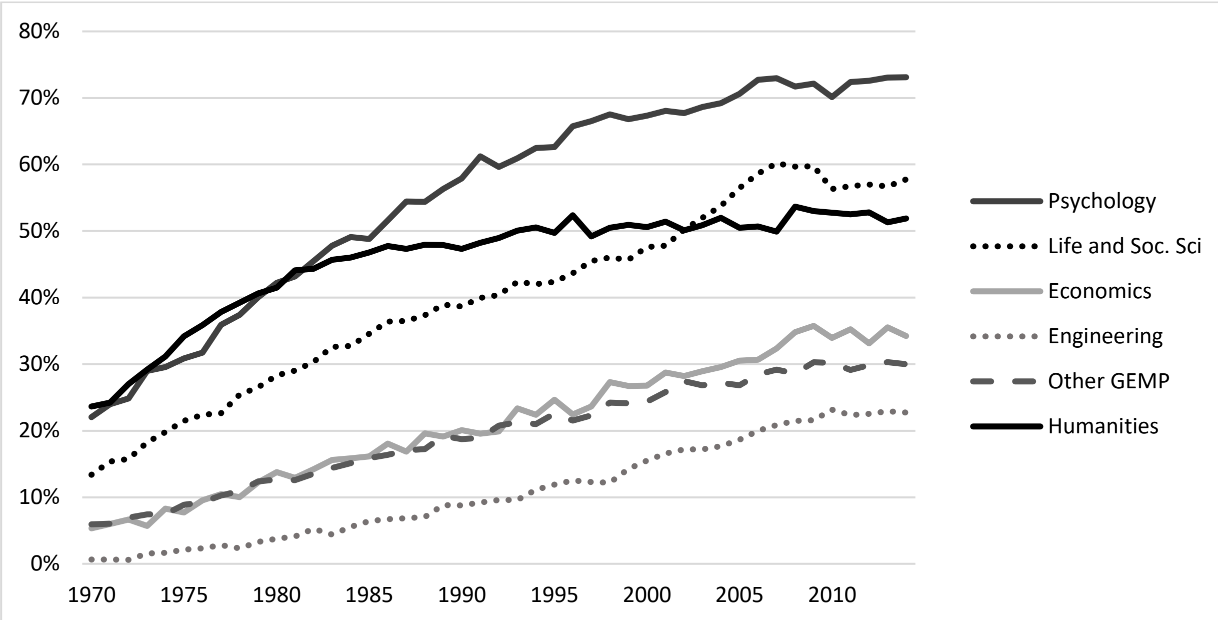
Sources:
Percentage female among high school graduates calculated as percentage female among high school (or higher) graduates aged 20–22 in the US Bureau of the Census's Current Population Survey.
Percentage female among college graduates by broad major calculated from NSF's WebCaspar system.

Figure 2: Percentage of Bachelors Who Graduate with PhDs Seven Years Later, by Broad Major Field and Gender



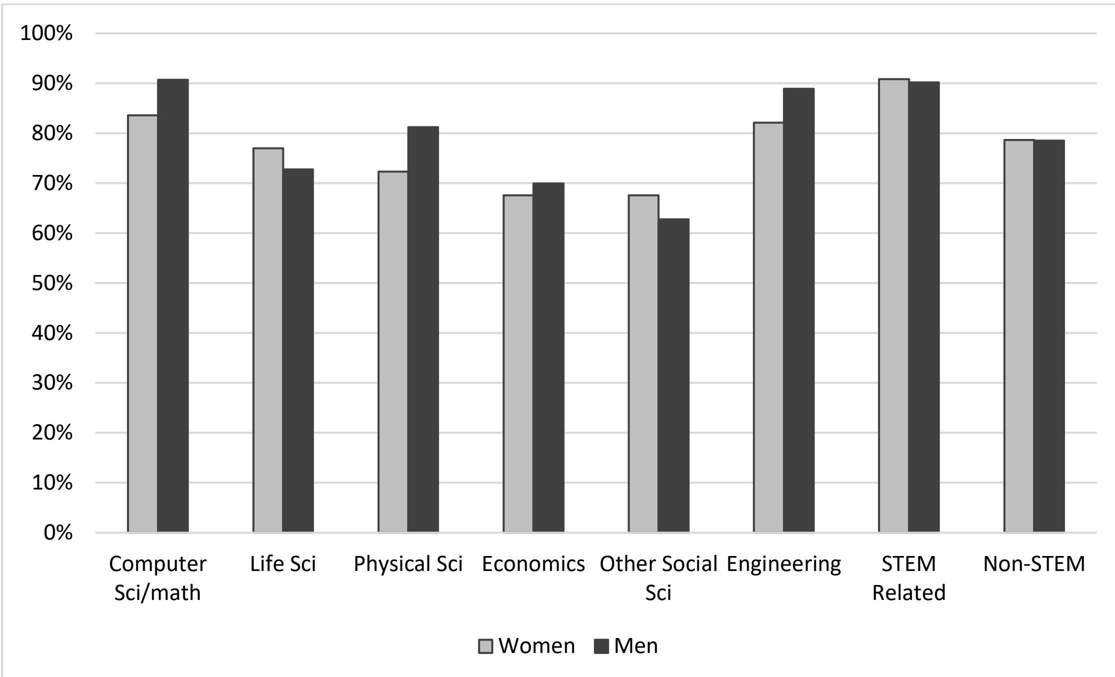
Source: Calculated from information on the numbers of female and male Bachelor's and PhD Degrees conferred in field. Source: 1992–2014 WebCaspar data.

Figure 3: Percent Female among PhDs Conferred by Field, U.S. 1970–2014



Source: Calculated from NSF's WebCaspar System.

Figure 4: Percentage Working in Jobs Related to Highest Degree, by Gender and Field of Highest Degree, U.S. 2013



Source: 2013 NSCG. Percentages shown include working in closely and somewhat related field.