Media's Impact on Women's Careers in the STEM Disciplines

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Introduction

A firestorm erupted this past summer over a technology company's recruiting ad that featured photos and statements from three of its engineers. What caused the uproar? It was not the words that accompanied the photo of one young software engineer—"My team is great. Everyone is smart, creative, and hilarious."—but rather the reaction to the photo of the engineer. Many who saw the print ad in the train stations and bus shelters assumed that the photo was that of a model portraying an engineer; the person pictured did not conform to the stereotype of an engineer. This unexpected reaction inspired the featured software engineer, a woman, to start the Twitter campaign #ILookLikeAnEngineer to dispel gender stereotypes of engineers. [1] More importantly, this campaign brought to the forefront the question of how engineers, and more broadly those with degrees in the science, technology, engineering, and mathematics (STEM) disciplines, are portrayed in the media and what impact that has on discouraging underrepresented groups from pursuing and persisting in STEM careers.

This is a timely discussion as it is well established that there is a critical shortage of science, technology, engineering, and mathematics (STEM) professionals. In the United States alone, it is estimated that one million more STEM professionals will be required for the country to maintain its excellence in science and technology. [2] There is not, however, agreement on what should be done to alleviate this shortage, as the reasons for why an individual does not pursue and persist in a career in the STEM disciplines are complex. What is clear is that STEM stereotypes perpetuated in the media—the geeky computer programmer, the bookish introverted scientist—have contributed to this shortage.

In 2012, the President's Council of Advisors on Science and Technology (PCAST) released a report that outlined a strategy to increase the number of STEM professionals in the United States by one million over the next 10 years. [2] This report acknowledged that much of this increase could be achieved simply by focusing on increasing the retention of college students in STEM majors by improving student engagement in introductory STEM courses: It is estimated that 60% of students who start higher education intending to major in a STEM discipline do not graduate with a degree in a STEM discipline. [2] It was also recognized that only increasing the retention of students pursuing STEM majors, however, would not be sufficient to meet the projected demand for STEM professionals in the United States. PCAST noted that the supply-demand gap can be closed only by increasing the numbers of women and minorities who pursue STEM degrees. Women and minorities comprise approximately 70% of all college students, yet are less likely to *obtain* a STEM degree and *persist* in the STEM field. [3]

This paper focuses specifically on issues regarding the underrepresentation of women in STEM disciplines. The concept of a "leaky" pipeline is often used to describe the progression of women through the educational system and into the STEM workforce. [4] At each educational and career step—primary and secondary school, higher education, workforce—fewer women persist to the next step. Since 2000, the percentage of women pursuing STEM majors has stagnated. [5] Also, more women than men depart a STEM major for a non-STEM major. [6] Finally, many women who graduate with a degree in a STEM discipline do not persist in a STEM career. [7, 8, 4, 9]

In this paper, I present a background on retention and persistence in the STEM disciplines to provide a common understanding of these issues; then address impediments to the

persistence of women in the STEM disciplines, and how visual cues and the media impact persistence.

Trends in STEM Degrees

Figure 1 presents the number of STEM degrees awarded in the U.S. at the bachelor's, master's, and doctorate levels from 1966 to 2012 (the most recent year that these data are available). Note that the majors that constitute the STEM fields can and do differ from one reporting agency to another. These data include STEM majors as defined by the National Science Foundation with the following exceptions: The number of degrees awarded in psychology and the social sciences have been removed from the totals, since these fields are not commonly thought of as being core STEM disciplines. In addition, these data do not include degrees awarded in health and medical sciences.

As shown in Figure 1, since 1966 the number of STEM degrees awarded has more than tripled for each degree, with the largest percentage increase seen for master's degrees. On the surface these data seem to indicate that the STEM fields are attracting more students, helping the U.S. to meet its goal of one million more STEM graduates over the next 10 years. This conclusion is not supported by the data shown in Figure 2. At the bachelor's and master's degree levels, the percentages of STEM graduates relative to the total number of graduates in the U.S. have decreased since 1966, and only a small increase in the number of doctorates is seen. In light of the greater national need for STEM professionals, this decrease in graduates at the bachelor's and master's levels is a cause for concern. [2]

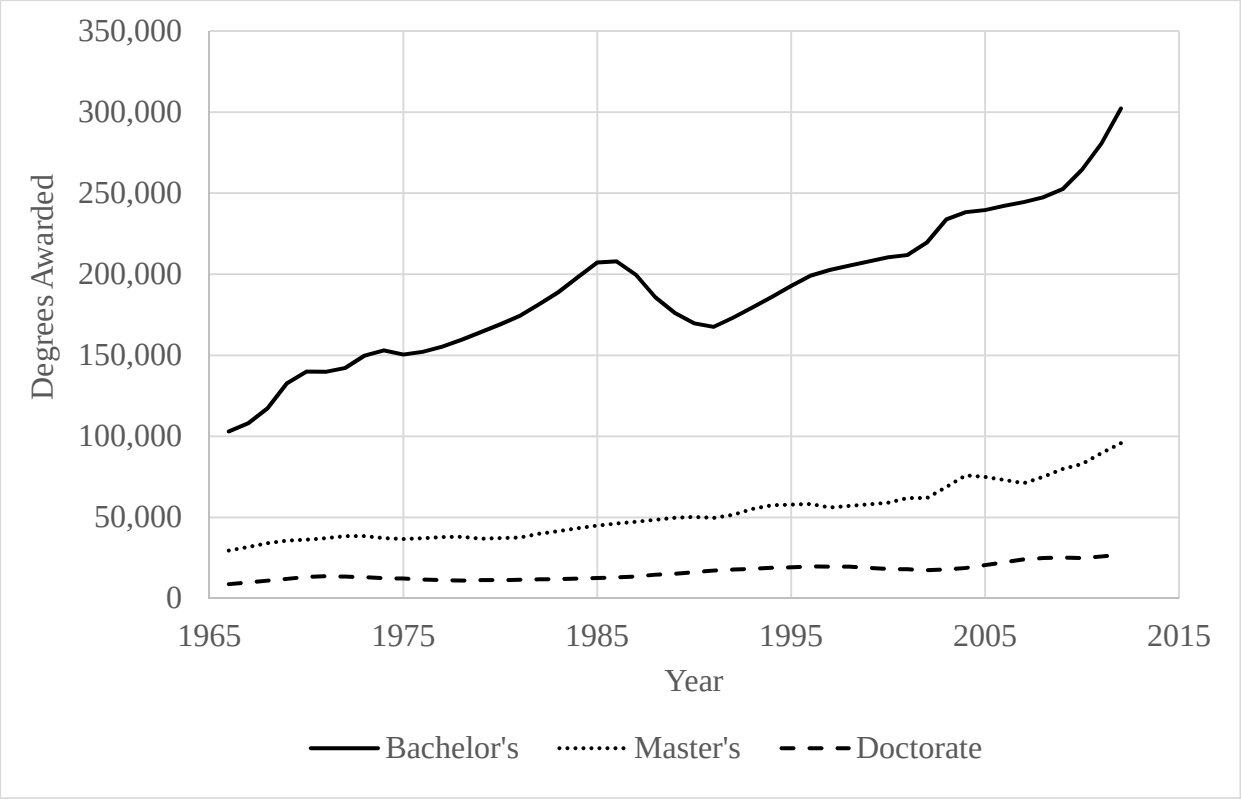

Figure 1. U.S. STEM Degrees Awarded from 1966 to 2012 [5]

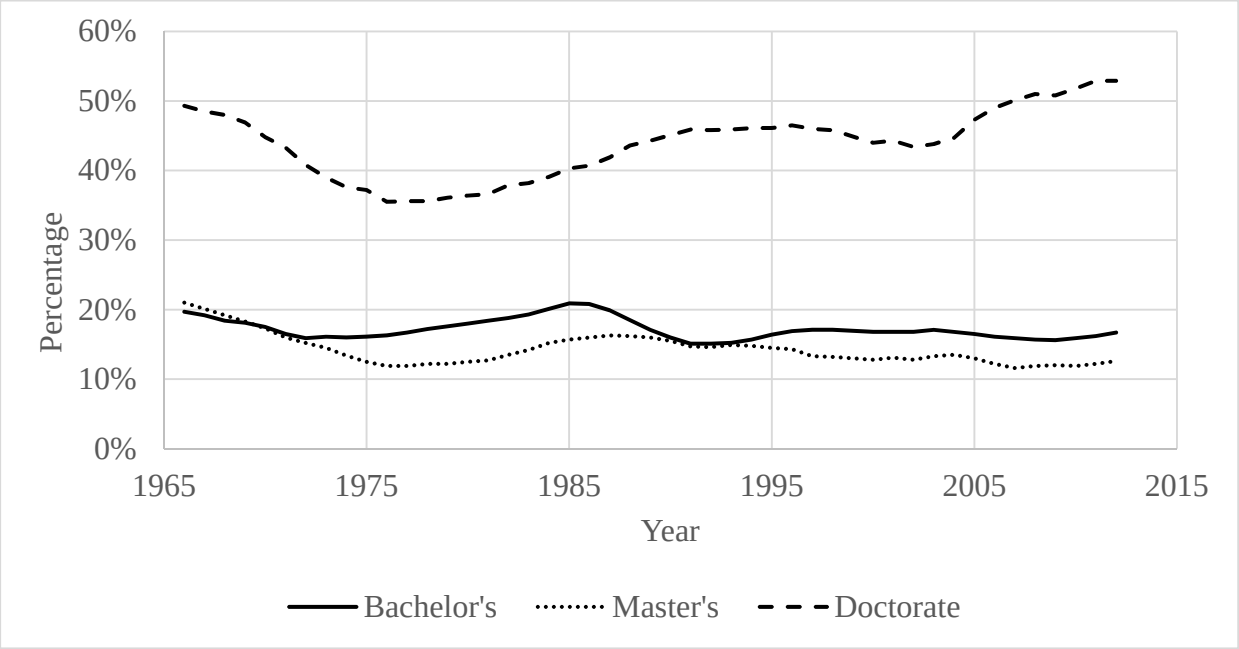

Figure 2. Percentages of Degrees Awarded in the STEM Disciplines Relative to Total Degrees Awarded in the U.S. from 1966 to 2012 [5]

As noted earlier, the need for more STEM professionals cannot be met by increasing the retention of students in the STEM majors alone. While the majority of college students are now women, women continue to be underrepresented in the STEM disciplines at all degree levels. The percentages of STEM degrees awarded to women relative to all STEM degrees awarded are shown in Figure 3. The percentages of STEM degrees awarded to women at all levels increases steadily until about 2000; from that time on, the percentages of bachelor's and master's degrees awarded to women in the STEM disciplines stagnates at 38% and 33% respectively. At the same time, the percentages of doctorate degrees awarded to women has not increased since 2009, plateauing at approximately 35%. The underrepresentation of women in the STEM degrees is noted by comparing the percentages of STEM degrees awarded to women to the percentages of all degrees awarded to women: 57%, 60%, and 46% for bachelor's, master's, and doctorate degrees, respectively. [5]

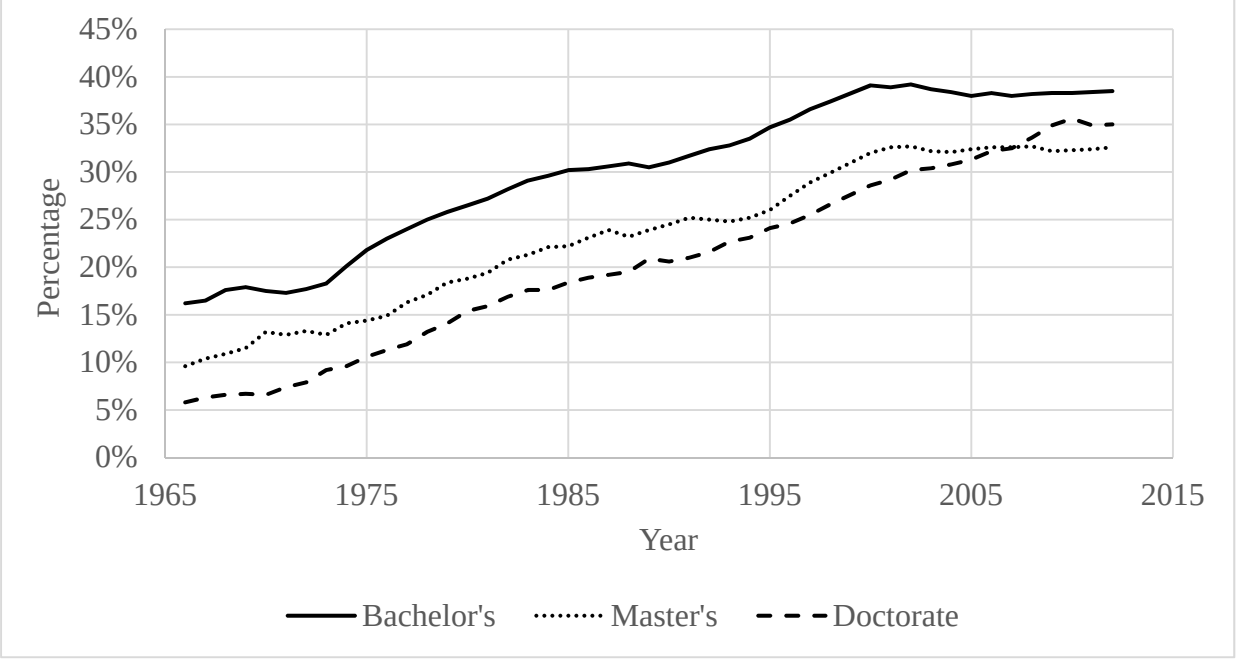

Figure 3. Percentage of STEM Degrees Awarded in the U.S. to Women from 1966 to 2012 [5]

The data shown in Figures 1 through 3 illustrate that while the absolute numbers of students obtaining STEM degrees has increased since 1966, the relative percentages of students obtaining bachelor's and master's degrees in the STEM fields has decreased. That is, more students are attending college and graduating with degrees, yet proportionally fewer are choosing to pursue a bachelor's or master's degree in a STEM field. In addition, greater numbers of women are obtaining STEM degrees, paralleling the increase in the numbers of women graduating with college degrees over this same time period, yet the relative proportions of women electing to obtain a degree in a STEM field have stagnated.

The contributors to this stagnation are identified by looking at the trends in different STEM disciplines. The percentages of women earning bachelor's degrees in selected STEM disciplines are shown in Figure 4; the degree data are provided for every five years, from 1967 to 2012. Also shown for comparison as a solid line is the overall percentage of women earning bachelor's degrees in 2012—57%. Women now earn close to 60% of the bachelor's degrees in biological sciences and approximately 50% of the bachelor's degrees in chemistry. In mathematics, the percentages of women earning a bachelor's degree have ranged between about 41% and 47% since 1977. In other disciplines, however, women earn significantly less than 50% of the bachelor's degrees. The percentages of women earning bachelor's degrees in computer science, engineering, and physics were less than 20% in each field in 2012. In addition, the percentages of women earning bachelor's degrees have stagnated or decreased since at least 2002 in all fields shown in Figure 4, and in computer science have shown a substantial decrease since 1987. Not only are women underrepresented in all STEM disciplines except for biological sciences, but also the relative proportion of women earning degrees in many STEM disciplines is decreasing.

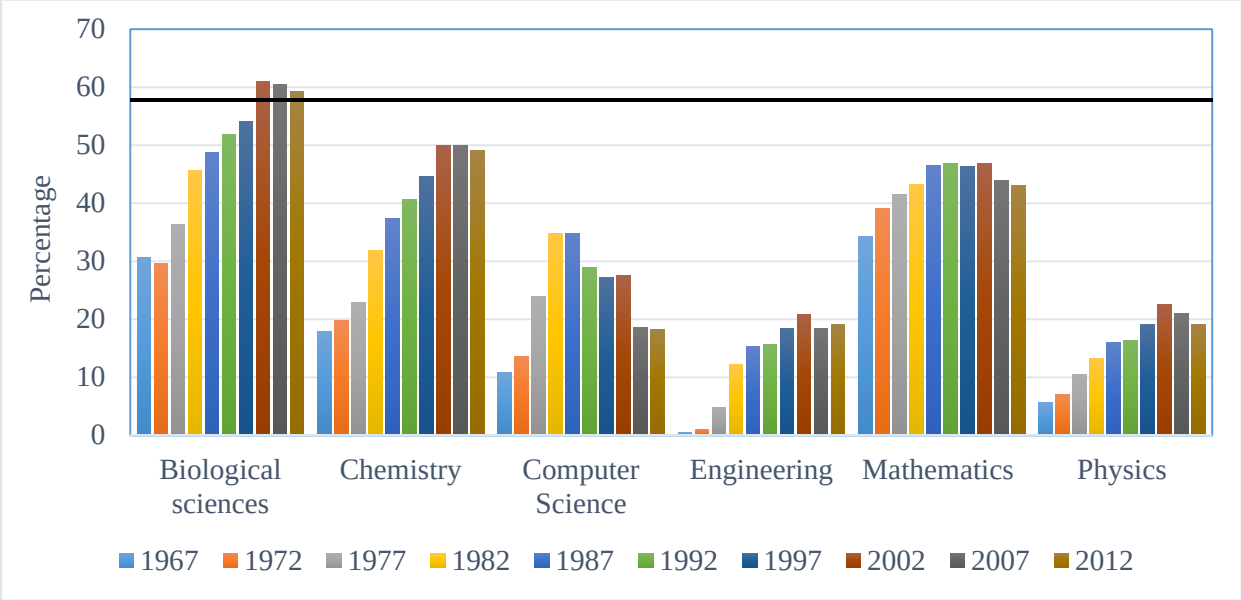

Figure 4. U.S. Bachelor's Degrees Earned by Women in Selected Fields from 1967 to 2012. The solid line at 57% is the overall percentage of women earning bachelor's degrees across all STEM and non-STEM disciplines. [5]

Compounding this underrepresentation of women among STEM graduates is that women are less likely than men to persist in a STEM career. Women leave STEM careers at a higher rate than do men: The U.S. Department of Commerce reported that college-educated women held 24% of the STEM jobs in 2009. In addition, while the percentage of college-educated women holding jobs increased to 49% from 46% from 2000 to 2009, the percentage of college-educated women holding STEM jobs remained constant at 24% over that same time period. [7]

The pipeline for women in the STEM fields is leaky. Efforts to increase the number of women in the STEM fields have been focused primarily on three areas: (1) increasing the number of women entering college with the intent to major in a STEM field; (2) improving the retention of women pursuing STEM degrees; and (3) increasing the number of women who persist in a STEM career. While there has been significant federal and foundation funding behind

these efforts, and a demand for more funding to expand these efforts, there has not been significant progress in these areas in the last 10 to 15 years. This suggests that there is something else affecting the dynamics of this problem. As an engineer and scientist, I propose that we have not identified the key independent variables that affect the outcome or that these variables have been beyond the control of the efforts to increase the number of women in the STEM fields. In the following sections, I examine the possible external influences that prevent women from ultimately pursuing meaningful careers in the STEM fields.

K-12: Outreach Initiatives, Biology, and Mixed Messages

The first step in addressing the leaky pipeline is to increase the number of women that pursue a STEM discipline in college; that is, to increase the input to the pipeline. Over the last 20 years, there have been significant efforts in developing K-12 outreach initiatives to stimulate the interest of both boys and girls in the STEM disciplines. Many states have mandated that engineering topics be integrated into the K-12 curriculum, and resources such as the TeachEngineering digital library with standards-aligned lessons have been developed with funding from the National Science Foundation. [10] In addition, many of these outreach initiatives have been directed specifically at stimulating the interest of young girls in STEM disciplines: Most major universities now offer summer science and engineering camps for middle and high school girls, for example.

These efforts have not been successful in engaging more women in the STEM disciplines, however. In a recent study of 2009 U.S. high school graduates, greater percentages of male graduates compared to female graduates expressed an interest in science and mathematics. [11] In addition, this study found that a gender divide persisted regarding advanced courses considered to be gateway courses for further study in the STEM disciplines. While more

female graduates earned credits for advanced math, chemistry, biology, and health sciences courses, more male high school graduates earned credits for advanced physics, engineering, and computer/information science courses. These data mirror the trends shown in Figure 4, in which many fewer women obtain bachelor's degrees in physics, engineering, and computer science compared to biological sciences, chemistry, and mathematics. Also, the percentages of women pursuing STEM degrees have stagnated, as shown in Figure 3.

Looking objectively at the K-12 outreach and integrated curricula "experiments," I conclude that other variables are exerting significant control on the outcomes. In the haste to implement K-12 initiatives, there has not been a careful experimental design performed to identify all of the independent variables that affect the numbers of women that are interested in and pursue a STEM discipline.

What appears to be a critical variable is the self-confidence of young girls. As was once thought, female students do not have a lower aptitude than male students for science and math. [12, 13, 14] Instead, many studies have shown that young girls are less confident in their abilities to succeed in subjects that require advanced science and math. Girls also exhibit a larger decrease in their self-confidence from elementary school to high school. As a result, girls predict less success in career fields that require advanced skills in math and science and are ultimately less likely to pursue a STEM career. [15]

If the K-12 initiatives are not improving young girls' self-confidence, what external factor might be at play? I assert that the prevalent gender stereotypes, both explicit and implicit, are undermining the efforts to encourage more young women to enter a STEM field.

Parents, as a child's first educator, and teachers play a significant role in the attitudes of young students, and gender stereotypes held by a parent or teacher will negatively impact the

self-confidence of a young student. [15] [16] Parents and teachers have been shown to praise girls in such a way that implies that girls' intelligence is fixed and boys' intelligence is malleable, for example. [16] The implication is that girls have a limited ability to learn new, complex material, while boys have the ability to succeed at mastering new material, and this leads girls to believe that they do not have the ability to succeed at academically difficult subjects. This attitude is seen when girls have difficulty in mathematics: Girls are more likely to explain their own difficulties in mathematics due to their lack of ability, while boys are more likely to explain their own difficulties due to the subject difficulty. [16] Despite equal ability in math as measured by standardized test scores, a much smaller percentage of girls than boys throughout K-12 self-report that they are "good at math." [15]

In addition, marketers and the media project gender stereotypes to the K-12 audience. Young girls who are already questioning their abilities in math and science are susceptible to internalizing these stereotypes. Consider the influence that Barbara Millicent Roberts has had on young girls. Barbara, better known as Barbie, is owned by an estimated 90% of girls three to 10 years old. [17] Mattel has been criticized for producing two Barbie dolls that sent the message that girls are not good at math and science. Teen Talk Barbie doll, introduced in 1992, randomly said four phrases selected from a library of 270 phrases, and one of those phrases perpetuated the stereotype that girls are not good at math: "Math class is tough." [18] Yes, math is tough, but that does not mean that girls cannot succeed in math. In response to complaints from the American Association of University Women, Mattel agreed to replace any of the Barbie dolls that said this phrase and to remove the phrase from the library. In 2010, Mattel released the book *Barbie: I Can Be a Computer Engineer*. While in the story Barbie intends to design a video game to illustrate how computers work, she ultimately is unable to achieve this goal and must rely on two

of her male colleagues to write the video game and to fix a computer virus on her computer. [19] Upon receiving many complaints, Mattel issued an apology and discontinued publication of the book.

It is not only toy companies that send the negative messages to girls about their academic abilities. In 2005, Abercrombie and Fitch sold a t-shirt with the following printed on the front: "Who needs brains when you have these?" This marketing effort received national attention when a group of teen girls from Allegheny County in Pennsylvania, known as Allegheny County Girls as Grantmakers, launched a "girlcott" against this shirt; the girls were unsuccessful in removing the shirt from the store's shelves, however. [20] In 2011, JC Penney introduced a t-shirt for girls that proclaimed, "I'm too pretty to do homework so my brother has to do it for me." [21] And, in that same year, Forever21 sold a t-shirt for girls with the saying, "Allergic to Algebra." [22] Both t-shirts were discontinued following negative press.

Despite studies that show girls have the aptitude to succeed at STEM subjects and numerous K-12 initiatives directed at engaging girls in STEM, the media continues to portray girls as less smart than boys and to downplay the academic abilities of girls. Coupled with negative messages received from parents and teachers regarding the ability of girls to learn new—and often difficult—material in technical areas, it is no surprise that fewer young women enroll in STEM majors as they enter college.

The Collegiate Years: Role Models, Stereotype Threats, and the Imposter Syndrome

The leaks from the pipeline continue as women progress through college. More women than men transfer from a STEM major into a non-STEM major, despite numerous programs to provide support systems for women in science and engineering. [6] The stagnation or decrease in

the percentages of women that graduate in the STEM fields tells us that these programs are not working, or at best are having a marginal effect.

Felder et al.'s 1995 study of an engineering student cohort from freshman year to graduation provides valuable insight into the gender differences related to persistence in engineering. [23] Prior to taking the first engineering course, the women were found to have better academic preparation and test-taking skills and a greater motivation to learn as compared to the men. In spite of their better academic preparation, however, the women in the study received lower grades in their engineering classes. Of significance was that the women were also found to have higher levels of anxiety and less confidence in their abilities prior to taking the first engineering course, and their confidence in solving complex problems decreased significantly as they moved through the curriculum. These findings are supported by a later study that demonstrated that women in an engineering discipline display less self-confidence in STEM courses than do men. [24] This corresponds to the lower self-confidence reported by female high school graduates in science and math.

A topic that is widely debated is the importance of female role models in the persistence of women in the STEM disciplines. [4] Since women tend to underestimate their potential for success, it is hypothesized that female role models in the STEM disciplines can help women to anticipate their own successes in the field. [25] Supporting this hypothesis is the finding from Felder's study that women in the engineering student cohort were more likely to have a mother trained in the sciences than were the men. [23] A recent study in computer science found, however, that the gender of the role model had no effect on success beliefs; rather, nonstereotypical role models led women to believe that they would be more successful in the field, while stereotypical role models had a negative effect on self-confidence and predicted

success in the field. [25] This was found to result from a perceived dissimilarity between the women and the stereotypical role models: in this case, the computer science "geek" whose favorite movie was *Star Wars*, whose hobbies included playing video games and programming, and who dressed unfashionably. These findings are supported by another study involving female students majoring in STEM disciplines: Female students' commitments to STEM careers are enhanced by seeing female experts who are relatable to the students, not female experts who embody the stereotypes of the disciplines. [26] [27] That females do not necessarily need a female role model is not surprising. Indeed, if the opposite were true, there would be many fewer female scientists and engineers 50+ years old, as not many female role models—stereotypical or not—were available when this cohort was in college.

Physical environment also plays a significant role in projecting perceived fit in a discipline. Female students exposed to classrooms that contained objects stereotypical of computer science—*Star Trek* poster, video games—were less likely to express an interest in the computer science field than those exposed to classrooms with nonstereotypical objects; the environment had no effect on the interest in the computer science field for men. [28] Likewise, among STEM majors, situational cues have been shown to affect how women (but not men) perceive their fit. Women who were exposed to promotional media for a conference that featured more men than women reported a diminished sense of belonging and less of a desire to participate in the conference than did women who were exposed to media that featured equal numbers of men and women. [29] This "social identity threat," or stereotype threat, has been proposed as a significant cause of the underrepresentation of women in the STEM disciplines, and a primary cause of the greater attrition of women from STEM majors. [30]

Another factor contributing to the loss of women from the STEM disciplines is the "imposter phenomenon," noted among high-achieving women who underestimate their academic abilities and believe that they have succeeded only because they have fooled others regarding their abilities. [31] The female students in Felder et al.'s study underestimated their grades in engineering courses and expressed less confidence in their abilities to solve complex problems. [23] The lack of self-confidence observed by women in STEM disciplines reinforces the imposter phenomenon.

Career: Persistence and Media Influences

The leaks from the pipeline continue after graduation. Only 24% of the STEM jobs were held by women in 2011, and this percentage has not changed since at least 2000. [7] During that same period, women received approximately 38% of the STEM bachelor's degrees. [5] In addition, despite the money and time spent on efforts to engage more young girls in STEM and to retain more women enrolled in STEM majors, women are more likely than men to pursue a non-STEM career after graduation. [7]

Why have these efforts failed? I believe that gender stereotypes and implicit biases continue to undermine women's self-confidence and sense of fit in a STEM career, to the point that women leave STEM careers at a higher rate than do men. It is the rare STEM female who has not heard the response, upon describing her degree and work to a casual acquaintance, "You don't look like an engineer (or biochemist, or computer scientist, or…)," or "That must be really difficult."

The media perpetuates gender stereotypes in its portrayal, or lack of portrayal, of women in STEM careers. A recent study analyzed the occurrences of women depicted in STEM careers in film and television between September 2006 and September 2009. In family films, 16.3% of

the characters with a STEM occupation were women, but none of these were in a leading role. In prime-time television, 21.1% of the characters with a STEM occupation were women, and in children's television, only one of eight characters (12.5%) with a STEM occupation was a woman. [32] Starting in childhood, the general population is hearing and seeing the message that not many women work in STEM careers. In addition, many of these women are depicted with "nerdy" physical and emotional characteristics.

By the time that women graduate with a STEM degree, they have been exposed to numerous stereotype threats. The women that persist in a STEM major are likely more able to recognize the threat and discount it, or at least are less susceptible to the effect of the threat. While in college a stereotype threat affects how a woman views her "fit" in the discipline, in the workforce a stereotype threat more broadly affects how a woman perceives the fit between her career choice and her life values, known as career-fit confidence. [33]

Career-fit confidence is closely linked to work-life balance. An often-cited reason that many women do not persist in a STEM career is because of difficulties in achieving an *expected* work-life balance. [4] The word "expected" is italicized because each woman has a different assumption regarding her desired work-life balance, and what is desired by any one woman changes throughout her career. A mother with young children likely has different expectations for work-life balance than a single woman or a woman with grown children.

The perceived ability to attain a "better" work-life balance is frequently cited as reason that more women than men select non-tenure track over tenure-track academic positions. [34, 35] For example, Birmingham and Wasburn's study of women engineering and technology faculty found that the majority of women who selected a non-tenure-track position did so because of work-life balance concerns, despite the improved job security and larger salary that come with a

tenured position. These women reported better work-life balance than did women in tenured and tenure-track positions, and were more likely to hold a part-time appointment. [35]

The tension felt by women to balance a “perfect” career and “perfect” life outside of a career is well-documented, and many women outside academia abandon their careers to resolve this tension. [36] The advent of social media has contributed significantly to this tension (e.g., “Pinterest stress” [37]). Carefully curated images of artful, hand-crafted decorations and of meals prepared from locally-sourced ingredients abound on social media sites, with the implicit message that this is the correct or expected way to live our lives.

Summary

#ILookLikeAnEngineer provided an outlet for women to dispel gender stereotypes of engineers. As a country, we must provide the freedom of choice and the opportunity for all women and men to pursue a STEM career if they are inclined to do so. Barriers to pursuing a degree or persisting in a STEM field must be removed for the leaky pipeline to be fixed, and this includes dispelling gender stereotypes. Young girls should not be told that they are too pretty to be smart or that they do not have the intelligence to learn advanced math and science. Collegiate women should not be exposed to gender stereotypes or physical environments that undermine their self-confidence. Women working in STEM careers should not be expected to conform to someone else’s idea of a scientist or engineer and what is the best way to craft a work-life balance.

All of us “look like an engineer.”

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