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INTRODUCTION

When my oldest son was in 7th grade, he joined the San Diego Math Circle, a weekend club for middle school and high school kids. Math Circle prepared kids for math competitions, and taught math topics not normally seen in school—voting theory, abstract algebra, computational complexity, fractals and Sierpinski triangles. Sophia[1] was a math whiz in my son's class, and she was perfect for Math Circle. I told Sophia's Mom about it, expecting an enthusiastic response, but she just rolled her eyes at me and said, "*You* talk to her." I was raising four boys, but she apparently knew something about girls that I didn't know.

So, I gamely talked to Sophia. I described the various topics, the occasional candy treats, the details of time and place, the two 15-student teams that had gone to Las Vegas to compete in ARML, the way math relay races work. And at the end of all this description, Sophia had one question for me, and one question only: *How many girls are in it?*

Of course, I'd always known about the gender gap in Science, Technology, Engineering and Math (STEM) fields. I had three degrees in electrical engineering and was an engineering professor. But here I was, face to face with one element of the *self-reinforcing nature of the gender gap*. A top-notch math girl didn't want to join a fabulous math club—because there weren't enough other girls in it.

I found this reluctance deeply discouraging. I want more girls to go into STEM careers. This short book is meant for young women going into STEM, and for parents of girls who may be thinking about STEM, as well as those not thinking about it. Social science research on gender in STEM is a great deal richer and deeper than it was 40 years ago, when I started high school. I want to transmit some things I've experienced myself as a female engineer, and other things I've learned from reading research papers, as well as from my own research. It amounts to a great deal of accumulated understanding I hope can be of some use for STEM girls starting on their educational and career pathways, and for their parents.

Before I go farther, I should perhaps say *why* I want more girls in STEM. People sometimes ask: Why does it matter what girls go into? If girls are freely choosing other fields, why is the profession they choose a problem? I'll give a few quick answers:

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1 Names of friends in this book have been changed.

- There's a shortage of STEM professionals in the United States. So, I want more girls to go into STEM careers, just because the United States needs more STEM people overall. It's not that I want boys to stop going into STEM careers. I don't. I want the boys to stay in. I just want more girls to go in, too.

- STEM jobs are high-paying and tend to be secure. I want women to have economic strength and job security. People often complain about the "gender wage gap," saying that women earn 80 cents for every dollar that a man makes. But these numbers are computed based on all women and men workers across all types of work, so a big chunk of that gap comes from women choosing careers that pay less. One way to close the wage gap is to have more women choose to become engineers or chemists, rather than choosing to go into traditionally female-typed occupations.

- The career and salary website, PayScale, recently did a survey [1] of 250,000 Americans who have at least a bachelor's degree. The survey found that "Fields that lead into high-earning or high-meaning jobs did see a larger portion of respondents that had no regrets about college." Humanities was the field most regretted—more than 20 percent of Humanities majors said they regretted their choice. English was the single most regretted major. Computer Science (CS) and Engineering majors had the lowest level of regret, with just four percent of CS majors and eight percent of Engineering majors saying they regretted their major. Since roughly 70 percent of Bachelor's degrees in English go to women, and only about 20 percent of Bachelor's degrees in CS and Engineering (in the Unites States) go to women—a lot of women are going into the most regretted major—and less women are going into the fields that come with the least regret.

- When we ask what's wrong "if girls are freely choosing other fields," we have to think about what it means to be *choosing freely*. Clearly, no one holds a gun to a girl's head and forces her to declare a major in some female-dominated field, rather than in mechanical engineering. But in wealthy Western countries, girls are subject to a relentless barrage of influences pushing them away from STEM. From the pink aisle in the toy store, to the little girl told not to examine bugs or plants because she will get her dress dirty, to the negative presentations of socially inept and fashion-challenged scientists on TV, to the guidance counselors who don't suggest engineering careers to girls, our society is an immersive soup of experiences that push girls away from STEM careers. By the time a girl is 18 and starting college, in what sense is she making a free choice?

- Women entering STEM change the actual technical work done in those fields. For example, Dr. Bernadine Healy became the first female head of the National Institutes of Health (NIH) in 1991, and she made a policy that NIH-funded clinical trials had to include both men and women, if the condition being studied affected both sexes. This mandate turned out to be extremely important, because women metabolize some drugs very differently, for example. The assumption that pharmaceutical doses that are correct for men can simply be scaled to women's body weights can be very damaging for women. In engineering, men design safety devices like seat belts and airbags with men in mind, initially causing much higher death rates for women. So, while the biology or engineering work women and men do is often equivalent, it is wrong to say that a scientist's or engineer's gender never makes a difference to the actual technical work.

- Women entering a STEM field not only change the actual technical work done in that field, they also change workplace culture. For example, women entering surgery have changed the way hospitals offer their surgeons various options of taking more calls, thereby earning more money; or taking calls less often, and earning less money. The fact that these tradeoffs now exist benefits everyone; male surgeons have more work-life options, too. In my own Electrical and Computer Engineering department, I've seen changes, as the number of women faculty went from one (just me) to seven. The women faculty are much more likely than the men to show up to events that support students (for example, a meet-and-greet with students, or an event to congratulate graduating students), and events that help departmental morale (staff appreciation lunches, faculty coffee hours).

This book contains summaries of research studies,[2] and my reflections on them, as well as anecdotes of my own personal experience. I recognize that I am trained as an electrical engineer, not as a sociologist or psychologist. I hope that this book can be useful with that perspective, not attempting to be some definitive work of psychology or sociology, but rather as the reflections of a female engineer who knows some of the bumps in the road for a girl going in to STEM. And who, like any civil engineer in road construction, is trying to smooth out those bumps.

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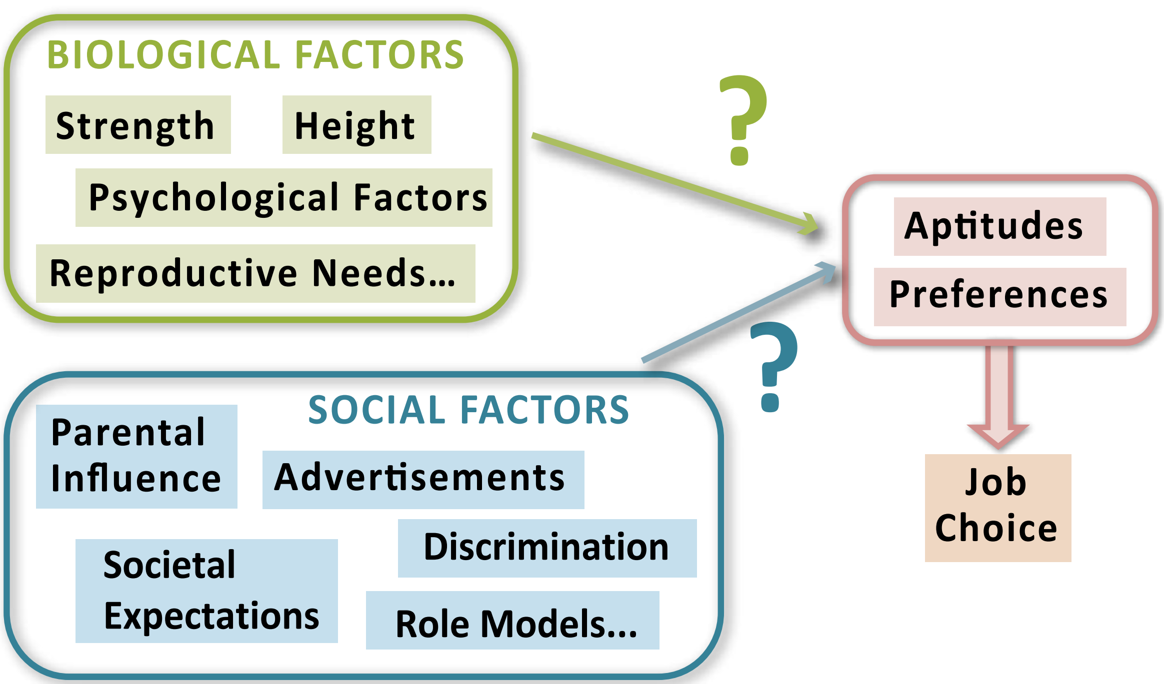
2 Chapter 11 presents one of my research studies. All the other studies summarized were not done by me.

BOYS AND GIRLS GOING INTO STEM

In 2005, Lawrence Summers, then president of Harvard University, speculated that one reason why there might be relatively few women in high positions in the science world was because of "intrinsic aptitude issues." These remarks provoked an uproar, and Summers was eventually forced to leave his position as Harvard president. Was the uproar justified? Let's look at the concepts in play here.

Aptitudes (what people are good at) and preferences (what people like to do) are key factors for many young people in choosing careers, and these aptitudes and preferences can be affected, to varying degrees, by biological factors and social factors. Of course, aptitudes and preferences are not the only determinants of career choice. A person can have tremendous natural talent for, say, flying an airplane; and a tremendous desire to do it, but she may lack the money to pay for lessons. So, that career option seems out of reach. But focusing here on aptitude and preferences, we can interpret the "intrinsic aptitude" of Summers' remarks as being aptitude determined by gender-related biological factors.



It’s easy to see gender-related biological factors playing a role in certain non-STEM fields. A basketball player needs to be tall; height is a biological factor that affects a person’s ability to dunk. And while both men and women have a distribution of heights, men are taller on the average. Height or strength may also affect a person’s preference, because people usually like what they’re good at. A firefighter needs to be strong to carry a person out of a burning building, so physical strength is a biological factor that confers aptitude for a firefighting career. And clearly, social factors are at work, too. Firefighters are mostly men, so it would be rare for a girl to find a woman firefighter as a role model; and lack of role models is a social factor. When we think about how gender affects one’s choice of a career—such as firefighter and basketball player—it is clear that *both* biological factors and social factors are involved. It is also clear that some biological factors (like height for basketball, and upper body strength for firefighting) stand out as obvious.

What about for STEM careers? Summers began his remarks by introducing three possible hypotheses that might account for the disproportionately small numbers of women at the top of science and engineering fields. The first was the “high-power job hypothesis”—the idea that women might shy away from careers demanding long hours and tremendous commitment. This hypothesis is, by itself, a very complex question—playing out differently in, say, law or chemistry; medicine or civil engineering. The second hypothesis was the “issue of intrinsic aptitude,” which lacked supporting evidence. That is, there was (and is) no evidence for STEM aptitude differential between the sexes, based on biological factors alone, when they are disentangled from social factors. His third hypothesis lumped together socialization and discrimination during job searches, which are vast sub-fields of research encompassing a myriad of different components.

Summers stated that, *in his view, the importance of the three hypotheses ranked in that order*. This statement was remarkably odd, given the complexity of the issues; the insufficiency of research on so many aspects; the absence of evidence for intrinsic aptitude difference; and the lack of data on the relative importance of all the factors. And as we will see in Chapter 6, believing in difference can produce actual difference—promoting beliefs in difference can have huge consequences. So, the uproar about Summers’ comments was justified, because whatever the intent behind them, they were unscientific and prejudicial. And while people are entitled to hold their own wrong opinions, Summers was making a statement in his capacity as president of a major university, a statement that was uninformed and damaging.

Another bizarre and unsupported statement appeared [2], in which Stuart Reges, a computer science professor at the University of Washington, opined in 2018 "…my honest view is that having 20 percent women in tech is probably the best we are likely to achieve." Where does this 20 percent come from? A few paragraphs earlier, Reges pointed out the percentage of women graduating with computer science degrees in the United States was roughly 20 percent, in 2018. Presumably, he got the number from that statistic—taking the 2018 U.S. value—and elevating it to the status of "best we are likely to achieve." But why should one take the percentage of graduating CS women in the United States in 2018, as the "best we are likely to achieve"? Why not choose the number for a different time or place, such as the percentage of women graduating in CS in the United States in 1984 (37 percent); or the percentage for India in 2015 (40 percent); or perhaps, the percentage for Malaysia in 2001 (52 percent)?

I think that both Summers' remarks in 2005, and Reges' writing in 2018, include statements based far too much on gut instinct and simplification of the issues. And I suspect this simplification represents how a lot of people think about these issues. As we will see, gut instinct can be utterly wrong on these issues, and ignoring real complexity can be really damaging.

In the next three chapters, I will summarize three trends about gender in STEM I found very shocking. The trends give some hint of the amazing complexity of the underlying social factors. These frankly counterintuitive results were important for me to realize that my own gut instincts were wrong, and that there is great deal more to learn than I had any idea of, even after three decades as a woman in engineering.