BREAKING THROUGH!

Helping Girls Succeed in Science, Technology, Engineering and Maths

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SECTION I

Introduction

Just a few years ago, if the acronym STEM had appeared in the title of a newspaper article, some might have speculated that a new government agency had just been established. And if the term STEM had been used in conversation, many people would have been puzzled, wondering why the discussion suddenly included a reference to the stalk of a plant. Today, however, STEM is widely used and understood, a reflection of the growing recognition of the critical importance of science, technology, engineering and maths for dealing with the complex issues that face us.

We hear about STEM breakthroughs almost every day. Yet women face obstacles in breaking through in certain STEM fields and in reaching leadership positions. This book describes the obstacles that have prevented females' full participation in STEM, but also focuses on the actions we can all take to make sure that girls have opportunities to be successful. Not only do an increasing number of jobs require knowledge of and experience with STEM fields and methods, but most aspects of everyday life rely on some degree of competence in those same areas. STEM provides us with a framework for understanding and

CHAPTER 1

STEM – Critical to the World, Crucial to Your Daughter's Future

> *I love that I can take a property that was completely derelict and return it to function. I do the construction draws for all of our projects. I love seeing new homeowners walk into their house for the first time after it has been completed.*
>
> – Nancy Hohmann, construction engineer, Director of Development for Lemay Housing Partnership, Missouri

On a typical day, you may use your phone to set an alarm, calculate a tip at a restaurant and send a text to your best friend. Using your computer or tablet, you might keep a budget on a spreadsheet, pay your bills online and check out the latest photos posted by your cousin on social media. You may not understand all aspects of the technology you're using, but they have become an integral part of your everyday life.

When the news covers climate change, an oil spill, the dangerous condition of a local bridge or the beginning of clinical trials for a new drug, your knowledge of STEM allows you to understand the information and to make educated decisions about your actions. You use maths skills to decide which size breakfast cereal is the best buy at the grocery store and your engineering know-how empowers you to fix a leaking toilet.

> *Information technology is an amazing career choice for women because it offers a wealth of opportunities. Not only does it provide a flexible work-life balance given the mobile nature of technology, but it is a rewarding industry as it allies people, business and innovation and relies on talent to drive its evolution. People may think you have to be innately technically minded, but the reality is very different. Success in the IT field is rooted in skills of strategic and critical thinking; with some focus and persistence, the technical side can be learned.*
>
> – Sheila Flavell, Chief Operating Officer of the FDM Group, London

The current over-representation of women in the social and life sciences and under-representation in other areas of STEM was not always the case. Data from the US Census Bureau on trends in women's employment from 1970 to 2011 show that women were once under-represented in *all* areas of STEM (Landivar, 2013). Even in the social sciences women were under-represented, making up just 17% of the workforce in 1970. At that time, the gender gap in all areas of science was quite similar (although there was a much greater gap in engineering where women made up only *3%* of the workforce). But some areas have made greater strides than others in achieving gender parity.

A curious fact is that women's employment in computer occupations grew significantly between 1970 and 1990 but then actually decreased, with women making up a similar proportion of computer workers in 2011 as they did in 1980 (Landivar, 2013). A 2014 story on NPR by Steve Henn attributed the drop in women in computer science to the rise in personal computers in the home. Early PCs were not particularly advanced and couldn't be used for much more than playing games (and some basic word processing). As such, they were marketed primarily as toys and particularly promoted to boys. The result was that boys were more likely to grow up playing with computers, leaving girls with less initial experience with computers when they got to computer science classes in university. The American Association of University Women (Corbett & Hill, 2015) agreed about the role the personal computer played in decreasing the number of women in computing, but also noted that women were originally a major part of the computing workforce and actually were the majority of programmers in World War II.

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What Do the Statistics Say About Women's Quantitative Abilities?

A common myth of why women are under-represented in STEM fields is that their natural quantitative abilities are not as strong as those of men. However, a review of the reasons for women's under-representation in science found that the evidence for a biological basis was contradictory and weak (Ceci, Williams, & Barnett, 2009). That doesn't mean that gender differences in maths ability don't exist at all, just that any differences are more likely to be caused by sociocultural factors rather than biological ones.

Although earlier research had found gender differences in maths performance, with boys outperforming girls on average, that is no longer the case, at least in the United States (Hyde & Mertz, 2009). Not surprisingly, the size of gender differences in maths performance in various countries is related to measures of gender equality. In other words, when women and men have equal status, they perform equally in maths. In addition, Riegle-Crumb and Humphries (2012), using data from the Education Longitudinal Survey of 2002 (a survey of a nationally representative sample of 15 000 Year 10 students) found that while Caucasian males outperformed all other groups in maths test scores, Caucasian females had higher GPAs in maths than Caucasian males. Furthermore, the advantage girls had over boys in their marks was greater among students in more advanced maths classes. Unfortunately, this study only used Caucasian males as the comparison group, so it is not possible to examine gender differences among other races or ethnicities in this study.

Some of the research that has looked at gender differences in maths ability has focused not on whether boys do better than girls on average, but whether more boys than girls get the top scores; presumably only those who have high scores in maths have the potential to succeed in fields that rely heavily on maths, which is true of many STEM fields. Once again, gender differences vary by culture and over time, indicating that societal factors are likely at play. However, unlike average scores, gender differences still exist if you look just at the top scores of

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Bias Against Women in the Workforce

An investigation into bias against females in hiring by science faculty at research universities was conducted by Moss-Racusin, Dovidio, Brescoll, Graham and Handelsman in 2012. About half of the faculty in the study were randomly assigned to receive an application with a female applicant name, while the others received the same application, but with a male applicant name. Female applicants were rated as less competent and less hireable and were offered lower starting salaries and less mentoring than the identical male applicants, by both male and female faculty. Statistical analyses showed that faculty were less likely to hire the female applicant *because* she was viewed as less competent. Not surprisingly, faculty who scored higher on a measure of "modern sexism" (which assesses unintentional negativity towards women) rated female applicants more negatively in terms of competence and hiring and offered female applicants less mentoring compared to faculty who were less sexist. However, faculty members' modern sexism scores did not affect their ratings of the male applicant. Interestingly, men and women faculty did not differ in their bias against female applicants.

> *Although a lot of faculty members who work with students at the college or graduate level consciously strive to support their progress, there are these internal biases that undermine the ways in which female students are assessed, rewarded, advanced and mentored in these STEM fields, which are traditionally and stereotypically male-dominated and thought of as masculine.*
>
> – Corinne A. Moss-Racusin, Ph.D., assistant professor of psychology at Skidmore University

Another study (Reuben, Sapienza, & Zingales, 2014) found that men were twice as likely as women to be hired for an arithmetic task (one that actually showed no gender differences). In addition, men tended to exaggerate their performance on the task, while women under-reported their performance, which led the bias to continue when those making hiring decisions were given candidates' self-reported past performance. Bias was only reduced, but still not eliminated, if objective measures of candidates' past performance were included.

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Do Role Models Have to Be Similar to Have an Impact?

Some studies have demonstrated that women are more powerful role models than men, resulting in female university students making more of an effort on a maths exam, having stronger feelings of competence in STEM and identifying implicitly more with STEM fields, and that these changes were driven by identification and feelings of connection with the role models (Stout, Dasgupta, Hunsinger, & McManus, 2011). However, exposure to female (as compared to male) role models did not reduce the stereotypes about STEM fields being "masculine domains". Stout and her colleagues suggested that women may be leaving the STEM school-to-work pipeline because they are not seeing sufficient numbers of same-sex role models in books, on television, in movies and in classrooms.

Many research investigations have specifically examined the effect of female role models on girls' and women's performance on maths exams. A meta-analysis (statistical analysis of results from multiple studies) by Weisz, Lawner, Quinn and Johnson (2015) found that while there is a small positive effect of female role models on female students' maths performance, this effect is only significant for studies that were done in the lab. In other words, female role models only seem to help students' performance when they are tested under very controlled conditions, rather than in a natural setting, such as a classroom. However, some of this may have to do with differences in the characteristics of role models in lab and field settings that may make them more or less effective. For example, the meta-analysis found that in lab studies, role models who were portrayed in a purely positive way were more effective than those who had some sort of undermining flaw, such as being doubtful of their abilities or not deserving their success. However, it should be noted that this particular analysis combined studies that looked at females' performance on a maths test with those that examined the performance of African American students on any sort of academic exam. In addition, the vast majority of these studies were done with middle school and university students, so it is unclear whether role models have the same effect on girls of other ages as well as on women. Among all field studies (those focusing on females and maths as well

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What Does Gender Bias Look Like?

Girls and women often note that they are more likely than males to be ignored or not called on in class or in meetings. Even in casual conversations, females say their opinions are often not sought or their ideas are quickly dismissed. Rather than feeling inferior when these situations occur (as if they don't deserve to be recognised), girls can use critical analysis to recognise a social pattern that is not about them personally, but rather is about the way bias manifests itself. As a parent, you can encourage your daughter and her friends to talk to each other about their classroom experiences, for example, to collectively identify patterns of behaviour that reflect unconscious bias. It is never too early for children to begin to learn about fairness. Even toddlers and preschoolers can exhibit empathy (Saliquist, Eisenberg, Spinrad, Eggum, & Gaertner, 2009).

> *Bias can be everywhere – even in the questions posed in textbooks.*
> – Ruthe Farmer, chief strategy and growth officer at the National Center for Women and Information Technology, Colorado

Girls can use data to find out the truth for themselves and use this information as a reality check and also for advocacy purposes. For instance, if a student learns that only 20% of girls at her secondary school are taking a calculus class but 75% were eligible, that would suggest a systemic issue. If girls are given the opportunity to develop their analytic skills, they will recognise that often it is the setting, rather than their talent, that is limiting their options.

The research described in previous chapters indicates the continuing existence of systemic barriers to girls' participation in STEM. Particularly as girls move through higher levels of education and the world of work, they are likely to encounter instances of discrimination. If they learn to build the resilience that allows them to solve problems as they run into tough situations, they are more likely to achieve success at a high level. Parents, teachers and program facilitators can find those teachable moments to ask questions and provide relevant examples,

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But that's part of using STEM in everyday life and it will serve her well now and in the future.

Which Media Figures Are Influencing Your Daughter?

As a parent, it's important for you to know what your daughter is watching on television or the computer. Learn who her favourite characters and actors are. Encourage her to understand the complexity of most characters. Help her differentiate between the role an actor is playing and what she is like in real life.

A study by Levine, Bowman, Kachinsky, Sola and Waite (2015) found that in one sample of parents, more than 65% of children younger than three were watching movies and television on mobile devices, such as phones and tablets, on a daily basis. And half of the parents in that study reported that their children were introduced to these devices before they turned 18 months old. Before you even think about monitoring what your young child is watching, you might want to think about when she should be introduced to computers, phones and tablets. Are there better ways for your child to learn when she's very young? In many instances the answer is "yes", because research (Kremar, 2014) suggests that infants and toddlers do not increase their vocabulary by exposure to DVDs. Interacting with responsive adults is better than passively watching a program (even a so-called educational one) on a screen.

As your daughter gets older, she will be increasingly exposed to media images – real, illustrated and animated. Sometimes, her exposure is indirect, such as when she is playing in a room where the television is turned on to a program you've selected for yourself. Although you may think she's fully engaged in her own activity, your daughter is probably picking up some of the messages from your show. As a key role model in her life, you give her important messages about using and interpreting media. The more you notice and question, the more your daughter will learn to do the same. Consider the following:

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