CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

THE EFFECTS OF GIRLS' SELF-EFFICACY ON THEIR INTEREST AND INVOLVEMENT IN MATHEMATICS AND SCIENCE

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ABSTRACT

The Effects of Girls' Self-Efficacy on Their Interest and Involvement in Mathematics and Science

By Mary E. Greenlee

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The development of self-efficacy, the belief you have in your ability to be successful at a task or subject, has a huge effect on a student of any gender in any subject. It is important to understand how and why poor self-efficacy is blamed for the genesis of young girls' lack of interest, involvement, and retention in mathematics and science studies and later, mathematics and science careers. Also noteworthy is how self-efficacy is greatly affected by the challenges of stereotype threat – a self-confirming belief that may endorse negative stereotypes. The sidling up of feelings of poor self-efficacy in girls starting prior to adolescence (specifically between third and fifth grade), and the negative consequences from this insidious phenomena, are examined in this paper, as well what positive and effective measures, including addressing motivation, are being taken to combat stereotype threat and reverse a socialization curse. Additionally, a staff professional development reveals how even the most earnest of educators can bring their gender biases and fixed mindsets into a classroom and obstruct the path for girls in mathematics and science. Finally, in a culminating event titled "Women in Math and Science for Youth" or "WIMSY",

supporting the growth mindset-based lifelong learner and their eager students, women from the community in Science, Technology, Engineering, and Mathematics (STEM) studies and careers face interactive audiences of children, grades kindergarten to fifth grade, sharing information, advice, and providing living female role models in STEM occupations.

CHAPTER ONE: INTRODUCTION

As both a teacher and the Gifted and Talented Education (GATE) Coordinator at my K-5 elementary school, season after season, year after academic year, I witness GATE-trained teachers bringing to our screening committee meetings thick portfolios full or work products of high-achieving, hard-working girls, and empty portfolios of boys whom the teachers may deem "quirky" or "out there" but nonetheless "verbally strong" and "creative" in mathematics or science, particularly in a science lab setting, so, "Why don't we just consider their anecdotal evidence?" is their thinking. While it is true that criteria for considering traits of giftedness is broad, and displays of giftedness do not always include a physical body of work, there exists a gender bias in this expectation of the presentation of evidence of work. In my own experience, this bias often positively highlights teachers' abilities to recognize a student's non-commensurate written and verbal abilities, but is unfortunately nonetheless skewed toward requiring girls' to have work products, and being very forgiving of the opposite gender, asking the boys to have little but their brilliant, tangential, cheeky oral responses to record.

This unintentional but significant bias – teachers having higher expectations of and greater amounts of written evidence for girls' giftedness, while allowing for boys to be playful, hands-on, and orally contributive, but not necessarily held to the same work production standards – got me thinking about how the new national education standards' focus on STEM subjects *could be (or not)* the great equalizer in recognizing all kinds of intellects, varying levels of giftedness, and different intellectual abilities.

The recent national push to focus on STEM subjects, particularly math and science, could very well lead many otherwise hardworking, ever-producing girls into subjects they may have not felt were wholly “their own”. The idea that math and science are male domains is not an established fact, but anachronistic ideas about boys as “better” in math and science, while girls are “better” in reading and writing. This stereotype deserves attention especially at this time in our education system’s history when our national interest is in building a capable twenty-first century education community and workforce, which should include competency and equitable representation in STEM fields. These old ideas about who is “naturally” better at what subject merit focus at least in terms of finding out why the notions seem to persist, despite evidence to the contrary. Who exactly thinks this way (and is perpetuating stereotypes), and what factors perhaps contribute to this thinking? Only then can we find answers to an insidious problem in education: girls develop chronic and poor academic self-efficacy perceptions in the later elementary and beyond school years about their math and science competencies, and these perceptions do not match true abilities, while they do often keep girls from pursuing STEM subjects and careers.

Girls may or may not feel they are on the same footing as boys in what has been thought of typically as male domains – mathematics and science. Additionally, the existence of stereotype threat, a phenomenon that requires a threat to a group’s identity, confirming the fear that a negative assignation is true, may affect girls’ diminished interest and involvement in mathematics and science. Henry Ford once said, “If you think you can’t, then you can’t.” Stereotype threat is kind of like that: if a teacher tells an equal number of girls and boys before a mathematics test, “You girls probably won’t do very well on this set of problems, seeing as girls aren’t so great at mathematics,” then the suggestion of inferiority may be significant enough to affect the group of girls’ overall performance on the test, even though each of the girls may have not doubted themselves until the threat existed.

Diminished interest and involvement for girls in mathematics and science should not be a problem in a first world, free-will democratic American society, but it is. In an Obama Administration Federal Science, Technology, Engineering, and Mathematics Strategic Plan, it was recorded that women make up nearly half of the national workforce, but hold less than 25 percent of STEM jobs. It is therefore vital to address this problem, especially as it concerns young, underrepresented populations, including and especially girls, as we must seek to prepare all students for twenty-first century STEM education pursuits and careers in a globalized, technology-driven world.

Self Efficacy

Self-efficacy is the perception of one’s abilities that “forecasts student persistence and achievement in challenging subjects” (Griggs, Rimm-Kaufmann, Merrit & Patton, 2013, p. 360). Factors that affect self-efficacy may include, but not be limited to, student notions of self, parents’ perceptions of their child and the subject matter, teacher perceptions of the student and knowledge of subject matter, a student’s cultural affiliations, socialization, and own exposure to subject material. Girls’ self-efficacy in mathematics and science may or may not be commensurate with true capacities, and may affect academic performance, interest, and involvement in mathematics and science beyond elementary school years. Self-efficacy plays a large role in shaping any thinking person's perceptions of their current abilities, and to that end, future interest and involvement in a subject or career. Research shows that between the third and fifth grade of a child's elementary school years, girls' self-efficacy, in math especially, diminishes. Despite no evidence that girls as a whole are doing poorly in the subject at this time, they generally ascribe both mathematics and science to be male-dominated domains. (Herbert & Stipek, 2005).

Girls' self-perceptions, educational environment, family, and cultural socialization all influence the trend toward gender-stereotype threat-based subjects such as mathematics and science. One writer speculated that gender stereotyping may be unconscious, and for example, given the assumption that girls struggle in math and science classes, parents may encourage their daughters to study more or provide them with more resources such as tutors or supplementary learning materials to help them to better in school. (Park, 2014). To ensure girls remain confident, interested, and involved in math and science, focused and effective measures in the school, home, and community-at-large must be put into place to ensure that girls will have space in the increasingly and all-important STEM-related careers in the U.S.

The cause and effect connection between self-efficacy, one's self-perception of one's abilities, and interest and involvement in an academic pursuit, begins with an individual. That individual is educated, socialized, and influenced by a number of factors. In the end, what that individual chooses to study or do (as a career) is wholly a matter of free will. However, if a girl, for example, feels, for a variety of reasons, shut out of an academic subject that let's say, is STEM-related, she will likely not study or pursue a STEM study or career. She will however, contribute to the statistics: less than 27 percent of our nation's STEM-related workforce is made up of women, while 52 percent of our total workforce is made up of women. Self-efficacy is the self-controlled, voluntary notion that you are whatever you believe you are, despite empirical evidence that may contradict your belief. Self-efficacy is connected to a student's strong sense of belonging as a learner that is found among children in primary grades, when young students demonstrate few concerns of qualms about performing well, and freely enjoy such subjects as mathematics and science, which may later be thought of as typically male domains.

Self-efficacy becomes fragile as girls confront what has been described as stereotype threat. Stereotype threat exists in the unconscious socialization and insidious messaging that makes an individual feel inferior about his or her affiliation with a group, and so, performs poorly and accordingly. Levels and kinds of socialization also have a profound effect on girls' self-efficacy, and are tied, as is motivation, to girls and women's interest and involvement in mathematics, science, and later, STEM fields.

The Project

Understanding the root causes of diminishing girls' self-efficacy in subjects such as mathematics and science is necessary in order for educators to address a problem with proactive solutions. A good deal of scholarly literature and research has led to breakthroughs in our thinking about girls' self-efficacy in classroom cultures at the elementary, middle, and high school levels. We also now have a better understanding of the unintended consequences of stereotypical thinking about girls' and women's abilities in mathematics and science, and what shifts in education are needed to combat stereotype threats to assure that more girls and women enter the STEM fields. This Project will address the following questions: (1) What does recent research indicate about school-age girls' sense of self-efficacy in mathematics and science? (2) What factors, such as stereotype threat barriers and socialization, contribute to the development of girls' poor self-perceptions, performance, interest, and further involvement in mathematics and science and affect girls' self-efficacy and belonging and in mathematics and science? (3) How can K-6 educators become aware of stereotype threat as a barrier to girls' access to studies, majors, and careers in STEM fields? And (4) What are effective classroom cultures, interactions, and activities in which educators can increase young girls' self-efficacy, sense of belonging, interest, and involvement in mathematics and science, such that these ways pave a road to girls' achievement and access to STEM studies and careers?

The literature review found in Chapter Two will show reasons why and how "belief structures in the general culture influence individual choices" (Hill, Corbett, & St. Rose, p. 49), what those belief structures are, why they exist, and what kind of turnarounds we can achieve in the education community to include, instead of exclude, women in STEM academic and career pursuits.

CHAPTER TWO: LITERATURE REVIEW

Girls' Self-Efficacy in Mathematics and Science

Young girls' tendency toward low self-efficacy in mathematics and science is apparent early in the elementary school years. One study concluded that girls rated their mathematics abilities lower than did boys beginning in third grade and continuing through fifth grade but there was no commensurate gender difference in actual math achievement (Herbert & Stipek, 2005). The time span in which girls develop self-efficacy is much longer than third through fifth grade, but it is noteworthy that as early as age six, a young girl's self-efficacy trajectory begins its descent. Girls at a young age may begin to be filled with self-doubt, a manifestation of the stereotype threat (ST). Therefore, it is important to define it within the context of girls in mathematics and science. A study of children as young as six years of age found that children did not necessarily "endorse" the boys-are-better-at-math gender stereotype, but rather, "manifested gender in-group favoritism (i.e., girls and boys reporting higher math abilities for their own gender group)" (Regner, et al., 2014, p. 19). Stereotype-based beliefs that boys are more competent than girls in mathematics, emerges during the elementary school years (Cvencel, Meltzoff, & Greenwald, 2011), which may help explain why boys believe themselves "more efficacious than girls" (Griggs, Rimm-Kaufmann, Merritt, & Patton, 2013, p. 362). Young boys and girls may be steadfastly confident about a lot of things at age six; they are learning many things for the first time and have little experience to compare or contrast abilities. What but socialization and gender attributes held by significant adults could draw young boys as young as six to believe they are better at mathematics than their female peers? The work of Shelley Correll, a Stanford University sociologist, suggests that "when cultural beliefs about male superiority exist in any area, even a fictitious one, girls assess their abilities in that area lower, judge themselves by a higher standard, and express less of a desire to pursue a career in that area than boys do" (Hill, Corbett, & St. Rose, p. 44).

In fact, another study similarly found no great gap between boys' and girls' ability levels in mathematics and science since the early 1980s. Heller and Zeigler (1996) found girls outperforming boys in some cases in these subjects, while they (the girls) often undervalued their abilities. They found no gender differences in fifth and sixth-grade students' science grades or test scores, but girls reported feeling less confident than boys in their ability to perform well on science tasks in the classroom (Bleeker & Jacobs, 2004). By the fifth or sixth grade, students appear to have gained the ability to see themselves as a member of a greater community of achievers—perhaps as competitors or simply a sense of belonging. Girls may have learned to undervalue their worth in terms of what they bring to the mathematics problem-solving or science lab table.

Altogether "findings underscore the importance of determining whether elementary girls believe themselves to be less efficacious in math and science and to intervene early and support their persistence in these subjects" (Griggs, et al., 2014, p. 363). A benign and simple declaration from a young girl of "I'm not good at math" could spur a hard look at what and why the child believes this is so. It might lead to an important self-reflection by each --the parent and teacher -- to consider if they have in any way contributed to this thought, and might lead educators seeking out knowledge and methods or proactive measures which can be taken to remedy this thinking.

Factors Affecting Girls' Self-Efficacy in Mathematics and Science

There are several factors affecting girls' self-efficacy leading to lower rates of girls' participation and involvement in mathematics and science. The first is stereotype threat (ST), where a self-perception of a kind is formed when a suggestion is made about a group with which a student is aligned. The second factor is socialization, which includes the effects of inherent biases and practices we have instilled in our students at home, in the classroom, and in our world. The third factor affecting girls' self-efficacy in mathematics and science is motivation, and this factor is so closely tied with the others, it is worth mentioning.

Stereotype Threat

Researchers Kerr & Robinson Kurpius (2004) found that if low self-efficacy persists, "this precarious blend of high aspirations and low confidence, of intellectual curiosity and desire to conform, the mathematics/science-gifted young woman in higher education enters an environment that is indifferent, if not hostile, to her intellectual goals" (p. 86). This "hostile" environment is largely a result of the stereotype threat phenomenon, wherein a suggestion of inferiority is made, and is a self-fulfilling prophecy.

Research delving into why girls believe themselves less competent in mathematics and science uncovers deep-seeded roots in a student's own self-perceptions, as mentioned above, and well as her educational environment and socialization. Regarding education, one researcher confessed, "Even if teachers behave gender fair, the culture of the classroom may subvert or override these attempts. The gender-specific behavior with which girls and boys begin physics lessons promotes the perception that the sciences are a male domain." (Hoffman, 2002, p. 454). Perhaps the subversive classroom is a regular everyday environment for the girls and they are simply shut out of the science lab, or mathematics problem-solving arena at a young, already pre-determined time in their lives due to what will be described in terms of socialization, and lack of strong female role models in those domains.

Socialization

A study focused on girls versus boys in terms of mathematics self-efficacy suggested that girls and boys might approach subject-related tasks differently because of social and biological influences. Researchers have found the girls to be more goal-oriented and willing to put effort into meeting academic goals, while the boys were more performance-oriented (Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006). This study itself shows the various aspects of socialization, including what we assign as predominant behavior in either a boy or girl (e.g., boys are performers, girls are planners).

What does this goal-oriented capacity girls may have mean in terms of socialization and in terms of girls' self-efficacy in mathematics and science? A Danish study concluded that the goal-oriented talent is soon lost, as a result of the effects of socialization, which steadily chips away at gifted girls' self confidence and aspirations. The researchers suggest that gifted girls tend to plateau in their abilities as soon as they become preoccupied with adolescent cares. Suddenly, boys take the lead in academic achievement – and it is a lead sustained throughout the rest of their lives. (Kreger-Silverman, 2013). Whereas girls can perform at the same level as boys, they often do not see themselves as having the same abilities as boys in math (Preckel et al, 2008). Adding to that thread, one study found that teachers often attributed gifted girls' success to hard work while gifted boys were given credit for their aptitude (Peterson, 2013). Bianco, Harris, Garrison-Wade, and Leech (2011) discovered that boys were "given more instructional time, teacher attention, and praise, and are called on more often than girls" (p. 172). These studies illustrate a personal point made in the Chapter One of this paper; girls often need to provide more proof of their competencies to get recognized. Boys simply need to participate to obtain some credit and get noticed.

One researcher theorized that a child's educational environment might result in girls retracting from STEM subjects in general. As girls become young adults, "girls experience ambivalent expectations: on the one hand, girls and young women have to present themselves as strong and self-confident in public. On the other hand, they know that being nice and caring is still very important. Pedagogy is challenged to give girls (and boys) support for coping with the multiplicity of gender which is attractive and difficult to manage at the same time." (Graff, 2013, p. 59).

Are teachers to blame for girls' poor self-efficacy in mathematics and science? In the aforementioned Herbert and Stipek study of girls' self-efficacy in mathematics versus language arts in elementary school grades, girls' mathematics competencies did not match the girls' poorer self-perceptions, and the girls even outperformed the boys in mathematics from third through fifth grade. The teachers did not, this study found, contribute to the perception that girls are not competent in mathematics; their ratings for the girls and the boys in mathematics were fairly accurate. Parents, however, rated boys' mathematics abilities higher than the girls', and did not even rate the girls' language arts abilities higher than the boys' abilities. The study showed that the parents' gender stereotyping was alive and well at the time of this research, which the researchers thought was a strong predictor or how the children themselves would self-rate (Herbert & Stipek, 2005). Parents may be the earliest influence on their children in terms of giving them validation about their competencies. If parents' perceptions are poor, inconsistent, or just plain wrong about a child' true abilities, this may affect the child's interest and involvement in a subject or task forevermore in a child's education and career.

Motivation

Single-sex education advocates and all education advocates would agree that motivation plays a role in student success in mathematics and science classes, much less any other subject. In fact, in one study of gender and motivation, girls placed in single-sex middle school science classes reported greater motivation, although girls in high school placed in a single-sex science classroom did not. (Johnson, 2012). Motivation may direct an individual's behavior. (Cherney & Campbell, 2011). What would motivate young girls to feel a sense of belonging in mathematics and science? Do we have enough images of women in mathematics and science on our walls, in our textbooks, and living female role models we can tap for information in the pursuit of mathematics and science? Ideally, the teacher and classroom environment itself would both motivate and promote equity and high expectations for all learners.

The idea that perhaps boys and girls approach academic tasks differently, and this affects motivation, has been explored. In a look at approaches to the way fifth and seventh grade students performed in mathematics, a study showed girls more likely than boys to "adopt mastery over performance goals, and subsequently use effortful strategies" (Kenney-Benson, et al, p. 23). In a paper focusing on predicting girls' motivation in English versus mathematics and science subjects (grouped together), the study used an Expectancy Model of Motivation (Eccles & Wigfield, 2002), which holds that students are likely to be motivated in subjects they value and where they expect to be successful. The English versus mathematics and science comparative study considered social and personal factors; social factors affecting a student's motivation are others' beliefs and behaviors, while personal factors include self-efficacy and one's own perceptions of gender roles. It was revealed in this study that in terms of social factors, learning about feminism and "exposure to gender-egalitarian attitudes" increased adolescent girls' mathematics and science motivation. In terms of personal factors, the big winner was peer support (not parental support) in terms of motivating young girls in math and science (Leaper, Farkas, & Brown, p. 281).

Researcher Jennifer Fink found that there are three major obstacles to girls' interest and motivation in STEM-related topics in school: stereotype threat, implicit bias in our culture, and a lack of awareness in the "depth and breadth of STEM" and to that end, she suggests some solutions to keep girls interested and motivated in STEM subjects. In the early years, children should be involved in hands-on problem solving in science tasks. In the third through fifth-grade years, students should be exposed to Carol Dweck's (Dweck, 2014) growth mindset possibilities – the idea that your ability in a subject is not innate, but rather malleable and able to develop. Although it was asserted, "Males may have an edge in spatial processing" (which is an intelligence that often goes hand-in-hand with engineering-type activities), Fink offers a caveat: that type of ability (spatial processing) can be improved with practice (Fink, 2015, pp. 24-25).

Among curriculum strategies that can be used with older elementary girls to increase motivation, interest, and participation in science are providing complex problems, longer wait-time, authentic assessment, and more class discussion (Baker, p. 18). If those education strategies tailor curriculum more to a young girl's sensibilities, then seeing the effects of those strategies may be helpful; many female scientists surveyed highlighted their early experiences in science in developing a life-long interest in science and in choosing their particular science careers. (Maltese and Tai, 2010). However, in terms of exposure of female role models and historical female figures in science, sometimes educators' own ignorance about women in the history in mathematics and science, and teachers' frequent implicit bias prevails often enough to send a message to girls that they don't have a future in science (Schmidt and Shumow, 2013).

Girls' Self-Efficacy, Performance, Interest, & Involvement in Mathematics and Science

What can be done to reverse the polarity of girls seeming self-sabotaging their performance, interest, and involvement in mathematics and science? One researcher extolled the virtues of early gifted identification because gifted girls tend to hide their talents to conform to social standards but often, “show less differences in early years, often attaining higher grades in math than their male gifted counterparts” (Peterson, 2013, p. 342).

Reverse the Socialization Curse

Educators need to take great pains to notice the effects of stereotype threat and reduced self efficacy among girls: “Because it appears that sex differences in interest levels emerge during childhood, educators and researchers must strive to (a) understand the factors that shape children’s occupational interest and goals, and (b) develop efficacious programs aimed at increasing girls’ interest in science” (Weisgram and Beigler, 2006). Moreover, educators and parents should become aware of implicit and explicit messaging that communicates the idea that girls are less academically able (Joet, Usher, & Bressoux, 2011). Providing effective training on ST and sense of belonging to teachers in mathematics and science and discussing ways to increase self-efficacy with counselors and teachers may positively affect both girls’ confidence and interest in mathematics and science. Last, getting parents on board, showing them how to encourage their daughters in math and science, is key. (Rabenberg, 2013). The timing of the message and the message itself must be clear: girls have historically been marginalized by their own poor self-efficacy in mathematics and science education. To not change our own bias and systems by which we approach these subjects is akin to blaming them (the girls) for developing poor self-perceptions about their competencies. We must take a long look at what educators and parents bring to the table in terms of gender bias and implicit or explicit message we send to girls, and to re-educate all.

Parents and businesses should take heed of their implicit or explicit messaging to both boys and girls. Take the example of Mattel Canada Inc.'s blunder in 1992, when they marketed a Barbie doll as a student whose prop was a sign that read "Math Class is Tough!" Complaints and critics across Canada who thought this reinforced a weak stereotype about girls and mathematics forced Mattel to agree not to use the exclamation with any future dolls, and offered to replace any of the dolls consumers wanted to return. (Taylor, 1995).

A French study shows that it is possible to encourage girls toward mathematics and science-related careers through "expert influence". (Selimbegovic, Chatard, & Mugny, 2007). Girls may also benefit from seeing themselves as scientists, and by getting more involved in interesting-to-them scientific pursuits and in turn, increase the "perseverance and resiliency" to pursue careers in science fields (Baker, 2013, p. 16). There must be something done to change what some researchers call the "feminine image of reading and writing" and "the masculine image of science." That context plays a role in perpetuating those stereotypes and gender expectations (Meece, Glienke, & Berg, 2005).

Modeling forward-thinking, excellent programming for girls, associations such as the Girl Scouts of America provide some hope: "The Girl Scouts of America are working hard to help shake the widely-held notion that young women don't thrive in the areas of science, technology, engineering, and math." The group teamed up with Lockheed Martin in a survey that found that 74 percent of teen girls are interested in STEM subjects, and are attracted to the hands-on, creative, leadership, and helping aspects of STEM careers. "New programs and recognition badges now focus on science and technology and aim at fostering the emergence of a generation of women who embrace technology and understand that a career in engineering is a matter of choice, and not a matter of gender" (Falcioni, 2012, p. 6).

Another source of excellent path-leading for girls was established in the form of Project Lead the Way (PLTW), a non-profit education company that promises a transformative experience to get and keep all children, and their teachers, grades K-12, interested and involved in, specifically, computer, engineering, and biomedical sciences. Over 8000 students in all fifty states have taken part in their courses and pathways to careers and college-readiness. For girls specifically, PLTW offers an engineering-for-girls promotional video and anecdotes of female student success, as well as lists of recent engineering scholarship descriptions and recipients.

Thinking about what occurs beyond the K-12 years, Edutopia contributor and educator Karen Purcell notes, "Without understanding the opportunities that are available to students of math and science, young women may think they have made a mistake when facing the challenges of completing a STEM major" (Purcell, 2015, para. 4). Purcell suggests summer internships, job shadowing and mentorship programs to allow the prospective girl-in-STEM-worker to witness a day in the life of that career woman. Purcell adds, "Teaming with a mentor is a career strategy that can bring huge benefits, especially to women in unbalanced work environments like engineering" (Purcell, 2015, para. 7).

If engaging girls in STEM studies and then steering young women toward STEM careers is the ultimate goal, the National Girls Collaborative Project (NGCP) meets the needs of a hungry-for-action women-in-STEM community. Aiming to serve and reach underrepresented girls in STEM, NGCP is a conduit, maximizing access to resources for their thirty-one individual collaboratives in thirty-four states, as well as individuals, including teachers and students interested in gaining support for and equity in their STEM programs. The non-profit, with funding from the National Science Foundation, provides a gamut of resources, such as professional development opportunities, best practices information, grants, webinars, and links to sites that may lead students and teachers to role models in STEM in their local area. One such link to a site called FabFems connects individuals virtually to one of many sites that may suggest female role models in the community or from a large company like NASA.

Introducing Instructional Alternatives

An all-girls school in Massachusetts has a simple 1990s blueprint for STEM success that may work today; single sex education, small learning pods where risk-taking and questions are encouraged, hands-on applications, and female role models (Kruschwitz & Peter, 1995). This would be ideal if it were not for the fact that access to public education, Title IX rules mean gender equity for all, and single-sex classrooms are not necessarily an option for public schools.

Other non-gender specific options for reducing diminished self-efficacy and promoting an inclusive education model include the employment of Complex Instruction, an educational approach developed by researchers Liz Cohen and Rachel Lotan (Cohen & Lotan, 1997) and heavily studied and promoted by Stanford University Academic Jo Boaler. This cooperative learning approach “aims to counter social and academic status differences in classrooms starting from the premise that status differences do not emerge because of particular students but because of group interactions" (Boaler, 2006, p. 4). This particular method of instruction was put into practice in a low-performing Bay area high school, with great results. Students "learned to appreciate the contributions of students from different cultural groups, genders, and attainment levels" (Boaler, 2006, p. 1), and to that end, cast a wide, equity net for range of students. Like Boaler, Lisa Jilk, a then-teacher at the Bay area school and now-Professor at Michigan State University, experienced first-hand, the benefits of complex instruction. Her work continues today, focusing on "re-culturing middle and high school math departments and building teachers' collective capacity to implement and sustain Complex Instruction practices, so that all students have opportunities to learn rich mathematics and understand how they are smart." (Jilk, 2015, para. 1).

Much like Jilk, Boaler, Cohen, and Lotan, Stanford Psychologist Carol Dweck developed and promotes a non-gender specific theory and practice of developing a "growth mindset." Dweck's theory is another alternative to completely eradicate gender-biased socialization. At the least, adhering to Dweck's theory would shift the perception of gender inequity to the notion that everything is develop-able, or a "growth mindset." If thinking ability is innate, women especially, Dweck found, hold on to a "gift mindset" (as if our intellectual capabilities were gifted to us at birth). Dweck's research on why women tend to avoid careers in mathematics and science found women tend to believe in the "gift mindset" as Dweck says, and this leads to many women eschewing careers in the sciences. In an inspirational and informational video, Dweck insists, "The harder the science, the stronger the stereotype about women" (Dweck, 2015). The result: women are turned off to seeking careers in those STEM fields. Dweck adds, "Males and females can both have a fixed mindset about math and science but it hurts girls more because they are on the negative end of the stereotype" (Bajajdec, 2013).

In response to the current STEM education trend, and to the possibility that there is a wide market to attract young, impressionable girls into STEM-related fields, there are many new organizations, beyond the Girls Scouts of America, that may fill a void for girls interested in science while schools are busy fulfilling every child's need. The list is long: Girls, Inc., Girls In Tech, Girls Who Code, Fab Fems, and The Bug Chicks, among other very specific organizations. There is Girl Up! -- a United Nations-sponsored, global vision non-profit that raises awareness and money for girls in places where it is hardest to be a girl and become educated. Locally, there is Iridescent Learning, a science-based tinker space for all located in Los Angeles. There is an organization called Do It Yourself (DIY) Girls, also Los Angeles-based, for girls seeking to simulate an engineering experience, but only for girls. The plethora of organizations ready to embrace the STEM wave and girls' interest and involvement displays the strong value our current culture has placed on STEM education in readying a competent twenty-first century workforce. Is it the market or the marketing? Either answer does not hurt, and only helps American girls in a quest to be on the same footing as the boys in the problem solving or playmaker space.

CHAPTER THREE: METHOD OF DEVELOPMENT

Resource Guide Overview for Maintaining Girls' Self-Efficacy

About the Author

Although I chose to be a teacher almost two decades ago, I have always had one foot in the "what should I be when I grow up?" door, and so try to make my career in teaching as exploratory as possible, just to see what more I can do and be. Every year, I elect a "project" to do. I have produced social justice-oriented plays. I achieved National Board certification. I have worked on getting grants and free things for the school and classroom. I adopt pet causes, attend students' outside school events, and collaborate in teacher-related book clubs with my colleagues. I decided to pursue a Master's degree. These are all endeavors that fulfill my desire to find out more about life experiences beyond what I fear – the rote classroom.

However, teaching fifth grade at my elementary school, Carpenter Community Charter in Studio City, California, a school of over 1000 students, has been anything but rote. My students and studies fill me with ideas about possibilities in life. One such possibility I found through my studies at California State University, Northridge (CSUN) in the Master's of STEM Curriculum and Instruction program is that girls may take greater control of their learning, especially in mathematics and science, and we educators must encourage that. I rediscovered this possibility as I asked about and researched girls' self-efficacy in mathematics and science and the consequences of not encouraging girls to pursue STEM studies and later on, careers. The findings were fascinating, and led me to make plans that would begin to educate others about a pressing issue worthy of regard and change. Soon, enough, I hope, as I continue in teaching another twenty years, this author will be able to appreciate the work others before her did to ensure equity and access to STEM studies and careers for all.

Implementation

As a teacher, sometimes you have to "backwards plan." This may not be a phrase recognized by any online or old fashioned hard cover dictionary, but backwards planning is a common and oft-used method for teachers to employ in planning curriculum and instruction with goals in mind, as they make sure they are meeting standards and providing benchmark objectives. In backwards planning, you think about what you want to accomplish, and formulate a step-by-step plan, walking backwards from the goal line.

As such, this multi-layered Master's degree project was formed with end products in mind and germinated starting sometime last spring, when research I had culled determined that girls and women avoiding STEM studies and careers – and do so because they face obstacles that are cautionary and preventable. I wanted students at my elementary school, whose rich childhood experiences already inform much of who they are, to hear the stories of and see modern, living, female STEM role models. I wanted the teachers at my school to be aware that there are women in our own school community who go to work in STEM-related fields every day, and they are precious resources to tap. "Who are they, what did they study, and how did they get to where they are now?" were some of the questions I wanted answered, once I found these intrepid role models, I invited them as guests to an event I planned called

"Women in Math and Science for Youth" (aptly appropriating the acronym "WIMSY").

The WIMSY event timeline started with the planning stages last spring. The idea of hosting a career day-type event where women in STEM fields would talk about their lives, and everyone would listen, was daunting but exciting. I began to compile a list of school community presenters, knowing and connecting in person with a few of the presenters personally. My aim was to procure as many women from the Carpenter community as possible. There would be strong, personal connections if the students could see each presenter as someone's Mom and a doctor, or someone's Mom and the "banker lady" (as one kid reported) who came and talked to our class about foreign currency. The guest list was compiled by late August, and the guest presenters, numbering 13, were confirmed by the first week in October. Each of the presenters represented a unique field in STEM studies or careers. This would ensure the presenters themselves would feel their contribution was unique, and the students and teachers would get to see a broad range of women in STEM fields. While some of the presenters were comfortable at the outset being asked to present to many students at once, and leave room for question and answer time, I continued to remain in contact with the presenters before the WIMSY event, offering any helpful advice about talking to rooms full of curious students. Most of the presenters wanted to share digital images, and needed technology I could arrange to be available. A brochure highlighting each presenter's background and credentials was also created and distributed to every student, teacher, and presenter. This allowed students to read up on interesting information about their presenters and possibly formulate questions before the presentations even began.

Invitees to the WIMSY event included all teachers and their students in all grades, and their classes. More than half the teaching staff signed up to attend the event, and over 480 students and staff took part in the event, which was lauded by one fifth-grade teacher as “phenomenal and inspirational.” Reminder notices about the event went out periodically before the date, to ensure punctuality and attendance. Attendance to the event meant you could choose up to three half-hour sessions with at least two presenters in each session. The entire "gig" lasted two hours, with rotations every half hour.

The theoretical framework for the WIMSY event was socio-culturally-based. The end goal was to change the culture of the school by getting our school community to see the women-in-STEM role models in our midst, and get teachers, administrators, and students to start talking about and planning for the future of all students, but particularly girls and women in STEM-related studies and careers. Unsure of whether the wonderful education the boys and girls receive at Carpenter Community Charter is gender-sensitive enough, the WIMSY event was designed with the idea that equity in education means exposure and access to not only curriculum and instruction in particular subjects, but also to role models who would inform the community about what (STEM-related field) opportunities are out there for all young people. I chose to plan for and create this WIMSY event because it would address a pervasive and insidious issue in American education and perhaps, sadly, in my own school community; girls, between third and fifth grade, begin to develop poor self-efficacy in mathematics and science subjects, and while the reasons vary, the profound effects lead to girls' lack of interest and involvement in STEM studies and careers, and a dearth of role models therein. If the young impressionable students saw their own community members in STEM fields talking about what they do for a living, describing how interesting their jobs may be, what kind of studies led to their choice of occupation, perhaps one life out of the almost 500 participants would be changed forever! (As it was, I received information that one young fourth grader decided on the spot that she wanted to be like the obstetrician presenter who spoke about delivering healthy babies).

Prior to this grand WIMSY event held on Monday, November 9, 2015, I also needed to fulfill a requirement to teach both staff and students a little something about engineering, and to that end, dispel teachers' fears about entering the world of teaching and doing engineering and design tasks, in the age of the new Next Generation Science Standards (NGSS). This is where my conceptual thinking began of how to integrate STEM-based teaching with gender-bias sensitivity, among other important aspects of teaching STEM subjects. With the assumption that many teachers would likely be apprehensive about teaching engineering, but must know that by revealing and contributing their own anxieties in any STEM studies or teachings, they would inadvertently hold young girls back, thus perpetuating a cycle of girls' disinterest and detachment from STEM studies and careers, I needed to start with engaging the staff with the encouraging words of wisdom from Stanford Psychologist Carol Dweck's growth mindset theory in my professional development held on a Tuesday staff meeting.

Carol Dweck's growth mindset psychology dichotomizes approaches to learning. If you enter a learning task with a fixed mindset, you may believe there is no opportunity for growth, what has been always will be, and maybe, possibly, your preconceived and simplistic notions of what you believe always to be true are self-fulfilling prophecies. What carmaker Henry Ford once said was appropriate here: "Whether you think you can or you think you can't, you're right" (Ford, n.d.). A "fixed" mindset keeps us from growing and changing. By contrast, a "growth" mindset allows for flexibility in thinking your abilities may change through practice, a development in greater understanding, and with the right set of positive circumstances (Dweck, 2014).

The notion of the growth mindset was introduced in a powerful one-hour plus interactive professional development forum with forty plus teachers and administrators. However, in the professional development I undertook, the planning and executing was rolled out in three parts. First, I offered a pre-professional development engineering task offering a range of students in different grades the chance to build simple machines to complete a simple task (rescuing a toy panda from a basket on the "ground" which could simulate hot lava, a flood plain, or an unruly ocean or river tide). I provided selected teachers and their students an opportunity to experience an engineering and design activity, then they gave me some input on what did and didn't work in the activity before the full staff professional development. This proved helpful in providing ideas on how to fully engage the staff in the engineering and design activity I had planned.

In the staff professional development, the teachers first took a pre-survey that revealed their beliefs about intelligence, perceived “male” and “female” academic domains, and their own willingness as teachers and life-long learners to develop skills or knowledge. Although results were not calculated until after the post-professional development survey, which was very similar to the pre-professional development survey, the majority of staff indicated the following: (1) they mostly did not believe intelligence is fixed; (2) there are “sometimes” gender-specific academic domains; (3) as teachers, they “often” (but not always) hold girls and boys to the same academic standards; (4) many would like to adapt the engineering and design activity we did in their classrooms; and (5) all would be interested in learning more about women in STEM, and would benefit from more exposure to ways to keep girls in the STEM pipeline. I chose questions on both the pre and post ends of the surveys that would highlight preconceived notions of gender bias to get teachers and administrators to start thinking about the type of mindset they bring to the planning and execution of their curriculum and instruction.

The pre and post-professional development surveys sandwiched an interactive viewing of a multimedia presentation I created to get the staff to consider the effects of stereotype threat, the development of girls’ poor self-efficacy and low motivation in mathematics and science, and the consequences of those conditions. Teachers and staff were introduced to the concept of Dweck’s growth mindset, and the benefits of being able to develop your mind, and equity practices to consider. Staff pondered. “What do I bring to the table when I teach mathematics or science?” And “Do I contribute to gender bias?” Or “Am I doing what I can to provide exposure to all students of female role models and promote their interest and involvement STEM-related work?" In short, the teachers were getting schooled in how to "Title Nine" their own minds, their classroom practices, and teaching environment.

Following this growth mindset presentation was an engaging engineering and design activity (a repeat for those who had done it in their classrooms). The task was (again) to build a simple machine with the tools provided (binder clip, twine, paper clip, basket, plastic panda bear) to rescue an animal in need, and with constraints (you couldn't touch the basket or animal, and could only use the machine to perform the rescue operation). It was clear from prior professional development experiences discussing our school's adoption of the Engineering is Elementary (EIE) curriculum (related, but not executed by me) that an overwhelming majority of teachers were entering the engineering and design realm with great trepidation. However, this activity was an ice breaker in terms of allowing all grade levels to access a science standard (understanding and explaining simple machines) that could span, be adapted to any grade level, and could be executed immediately in class the next day. Those who did reported the activity with their class was "fun", "easy" and for some, "fast." I chose this engineering and design activity to accompany the multimedia presentation on the growth mindset for the reasons illuminated in the teacher feedback; it was a great activity to use following a discussion about a growth mindset, and the teachers illustrated how although they had reservations about engineering and design, they were open-minded and considerate of the task's design itself. It was revealed in the multimedia presentation that girls find engineering and design activities much more engaging if they are (a) non-competitive; and (b) helping someone or something. No one could resist helping a simulated stranded panda!

Resource Guide Overview

It is important to note that implementation of this “project” was piecemeal in its delivery, but the cause and effect connections to be made were strong and hopefully, hard-hitting; for girls, stereotype threat, the onset of poor self-efficacy, and ensuing low motivation all remain factors that affect girls’ interest and involvement in mathematics and science and other STEM-related studies and careers. The fixed mindset, whether held by a student or teacher, can also affect girls’ STEM pipeline avoidance. Having successful (female STEM) role models in the community can bring energy and hope to students who need to see to believe that women in STEM fields can contribute immensely, and help to start chip away at preconceived notions anyone holds about girls’ and women’s abilities in STEM studies and careers. This is why a website platform called Weebly was determined to be the best site on which to build an informational how-to and all-in-one resource guide for like-minded people thinking of tapping in to their community’s own resources to get the word out about girls and women in STEM. Using the Weebly site to model how role models in STEM can help build your community of STEM leaders is a first step toward making women in STEM no longer a problem but a ubiquitous solution.

CHAPTER FOUR: RESOURCE GUIDE

Resource Guide for Educating the Community about Girls' in STEM and the Importance of Role Models

Educating the Public

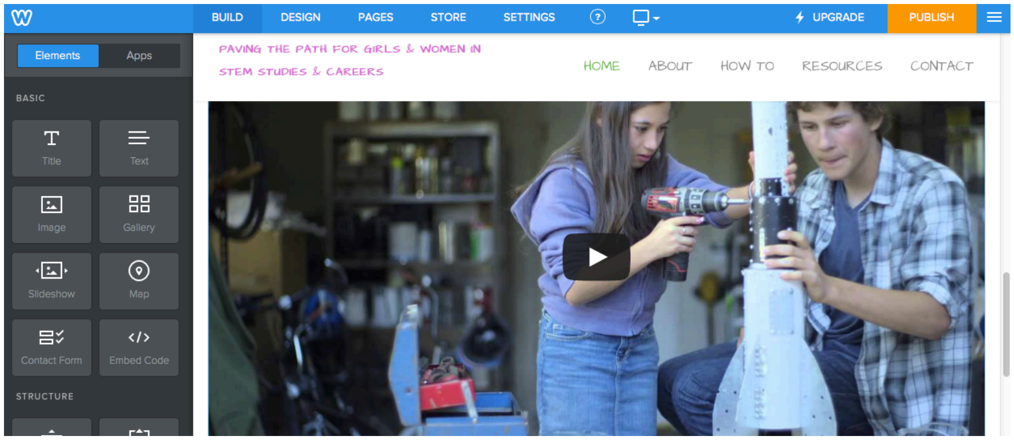
Educating the public about the effects of girls' lack of interest and involvement in mathematics and science and other STEM-related studies and careers starts with data. The platform in which this data, among other interesting and relevant pieces of information, is best displayed and disseminated, is in a Weebly website page. Weebly is a webpage builder and host site for anything from businesses to restaurant menus to a how-to page for hobbyists, entrepreneurs, or bloggers. These are just several of the many types of Weebly sites out there. My Weebly site is one of them: **http://carpenterwimsy.weebly.com** is available to any interested party with a computer, iPad, or smart phone capability.

Over thirty million Weebly users cannot lie; Weebly is an effective site-building platform. My task was to create a site that would not just be neat to view, but would also disseminate information about a topic – girls and women in STEM and how the presence of role models can help build interest and involvement therein – and keep as many interested parties as possible referring to the site.

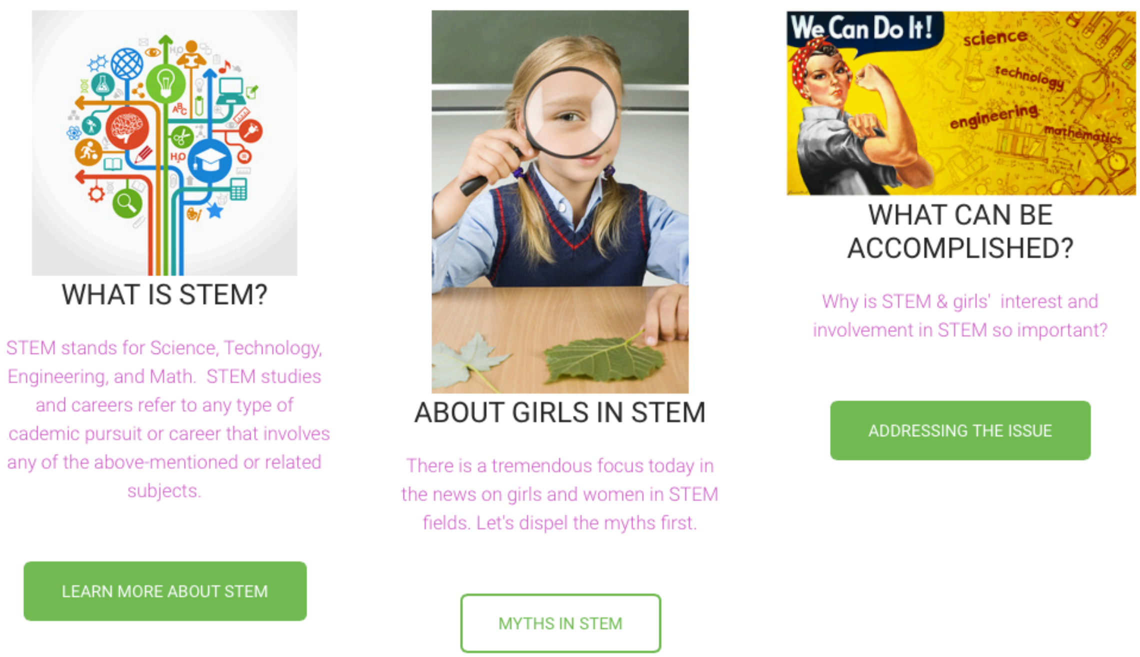
As a Weebly design template, I chose to use a soft filter that showed a silhouette of a Barbie doll Engineer. Although unable to see the model well, this doll, with her brown skin, lab coat, laptop, and professional look, is the very archetype of a woman whom we do not see enough of in print images, books, magazine or online stories. I want this image to hit home and make the message slightly ironic; even

Barbie, forever the epitome of unrealistic physical standards and generally white and blonde, and uninterested in anything other than her ephemeral possessions, can model new thinking, a growth mindset of sorts, and begin to help change the culture of males or "types" of females occupying certain domains. Role models in STEM studies and careers can pave that path, and the Weebly site provides the reasons why the path must be trodden, and how.

The Weebly site contains several different pages and links. The Home page welcomes the reader with a video from Verizon that introduces the notion of the prevalence of gender bias. The Home page also promises the reader more information and resources to counter this bias, marketing the idea of moving on in the site.



In the About page, there is a main section that defines STEM studies and careers, acknowledges the education community's recent focus on girls in STEM and the future of a nation's STEM workforce, and provides links to address some hot-button issues concerning girls and women in STEM.



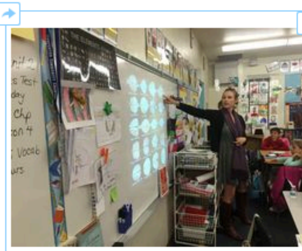
Beyond the main About page information, there are four subsections. The first subsection allows the viewer to read bullet-pointed facts about the cause and effect connections of girls being kept from the playmaker space, STEM lab, and

STEM studies and careers in general. The information reported contains facts, but they are revealed in a sequential way such that the reader can see the link between girls' poor self-efficacy in subjects such as mathematics and science, beginning as early as eight years old, and how this early experience may lead to a lifetime of a girl or woman being kept out of STEM studies and careers. In the next subsection, the About subpage called "Leaky Pipeline" lists factors girls face in the course of applying themselves to STEM subjects. This sub-page offers a revealing video that highlights examples of socialized and institutionalized gender bias thinking. These and other videos embedded within the Weebly site support the site's written content and provide multimedia diversions from the written work, hoping to hold the site readers' attention. In the third subsection of the About page, the notion of Stanford Psychologist and author Carol Dweck's growth mindset is defined in basic terms. A short video explaining the difference between a fixed versus growth mindset delineates the two strains of thought, and helps ensure general understanding. In the fourth subsection, viewers find a way to learn out more about the site author and the genesis of this project which may prove interesting for some site visitors if they have considered similar ideas.

Stanford Psychologist and author of Mindset Carol Dweck proposes having a growth mindset versus a fixed mindset, where intelligence is fluid, rather than fixed. This serves to combat stereotype threat and promote developing strong self-efficacy and greater motivation.

In the How-to page of the Weebly, a chronological list of tasks and considerations is provided for the intrepid Women in Math and Science for Youth (WIMSY) event planner. Additionally, there are anecdotal photos and captions from my own WIMSY event. Looking back, I believe these photos must provide inspiration for the next time anyone including me, wants to plan and execute such an event.

WIMSY What?


University of Southern California (USC) Brain Researcher Dr. Kristina Uban talks to students at Carpenter Community Charter about different parts of the brain.

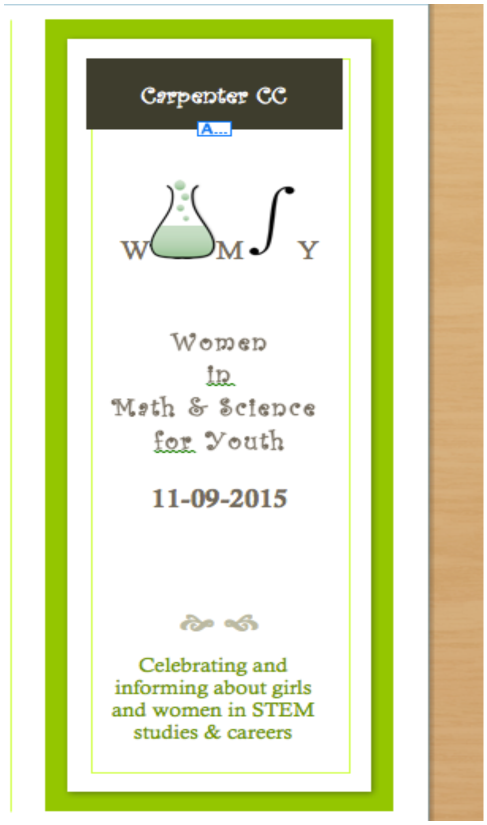
Women in Math and Science for Youth (WIMSY) Day was born as I trolled the school library and classroom and decided there were not enough books, posters, or references to female role models in history, math, and science. I myself had Nelson Mandela and Einstein posters, but no literature or visuals of great women of any domain. I needed to Title IX my own classroom for starters. I wanted the whole school to do a self-check too. To kickstart focus on women's contributions in math and science, I decided to plan this WIMSY event. Yes, that acronym is my creation.

The end goal hosting a Women in Math and Science for Youth (WIMSY) event was to get our school community to see the women-in-STEM role models in our midst, and get teachers, administrators, and students to start talking about and planning for the future of all students, but particularly girls and women in STEM-related studies and careers. The event was designed with the idea that equity in education means exposure and access to not only curriculum and instruction in particular subjects, but also to role models who inform the community about what (STEM-related field) opportunities are out there for all young people.

The most important aspect of developing a site you hope viewers will visit and use is providing useful content. Therefore, the Resource page of this Weebly affords a long and varied list of Internet and other resources for those interested in finding out more about developing a strong sense of and or program of girls in STEM studies and careers.

Educating the Teachers

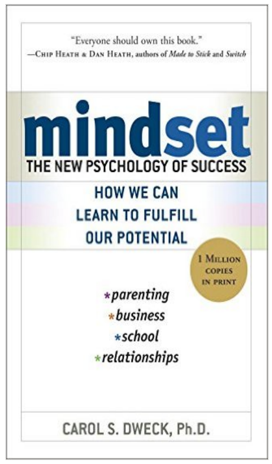
Establishing a rapport with my own teaching and learning community was integral to the success of the WIMSY event and the Weebly framework. I first planned and conducted a professional development more than a month in advance of WIMSY, that became a resource itself, in which I introduced the notions of gender bias in teaching, especially in mathematics and science, and proposed the idea of Carol Dweck's growth mindset to the my school teaching staff. Several copies of Dweck's book, Mindset, were distributed, and together, we identified the significance of the basic tenets regarding a growth mindset. Over forty teachers and administrators participated in the professional development, which culminated in a collaborative engineering and design activity, tailor-made to underscore the importance of finding ways to keep girls interested and involved in such activities (if they know they are helping someone or something, they maintain interest, and this activity gave participants that opportunity). This professional development served as a foundation of interest and involvement for the idea itself of girls and women in STEM, and the importance of live role models in our community. Interest piqued when over 480 students and their teachers attended the WIMSY event one month later.



The role of the professional development presenter and expert on the research on girls and women in STEM as a catalytic resource cannot be understated. If planning a WIMSY-type event, it is imperative to have and present facts and figures to get “buy in” from your colleagues and administration. The ultimate objective is to educate about the dearth of girls and women in STEM studies and careers, and to begin to eliminate fixed mindsets based on stereotype threat, lack of exposure to experiences, such as the kind role models provide, and general biases.

Educating the Students

Although I did not set out to provide a Resource guide regarding girls and women in STEM for students, the Resource page on the Weebly addresses and affects students’ concerns. The most important resource for the students, however, is one’s own mindset. If a student can manage to believe that skills and knowledge can develop over time, that intelligence is not fixed, then a student at any age can experience the benefits of the growth mindset.



CHAPTER FIVE: IMPLICATIONS

Consider the effects of forty plus teachers hearing and reading about statistics on girls' plummeting interest and involvement in mathematics in science starting as early as age eight. Let's say all of those teachers listened attentively at a professional development presentation and discussion, are affected by this current news, and want to do something about keeping girls in the STEM pipeline. Those same teachers participate in engineering and design lesson activities that could be tailored to specific grade levels or types of learners, and hold girls' interest, and these teachers immediately bring this engaging lesson back to their classrooms of thirty students, half of them girls. Later, over five hundred students attend an event that highlights strong, capable female community members (many of them mothers of children at the school) who happen to be making livings and careers out of STEM-related studies and work. The students are impressed, and think how some of the presenters' ideas and words reminded them of an engineering experiment they did in class. The students think perhaps they have never met someone who researches the brain for a living. The teachers who have taken part in the professional development and career day-type event feel their education is coming full circle. The presenters felt welcome and were inspired by the students' questions. They vow to return next year and inspire more students to become doctors, researchers, designers, bankers, and architects. The students write thank you notes that move the presenters to think, "Wow, I really made a difference in some child's life today, besides all the other work I do, delivering healthy babies, or developing a technology application." The kids dream and talk about STEM studies and careers, and perhaps, one day, make a firm decision to enter college declaring a mathematics major, or settle on a career in medicine, or explore the world through paleontology. The possibilities are endless.

Here is what has happened so far in the short time after the Women in Math and Science for Youth (WIMSY) event occurred. A fifth-grade girl declared she wanted to be a banker one day and "handle all kinds of money". Another student announced she would like to become an obstetrician after hearing one of our community members talk about delivering healthy babies even when she treats high-risk pregnancy mothers. Another student pledged to become just like a Chief Financial Officer (CFO) who would be able to decide which rides could work best and be most profitable at Universal Studios. A teacher declared, "All those high school girls who came and spoke today should get scholarships to college. They are so passionate and involved in their Science clubs!" It is clear that the expert influence had influence, and a large section of the school community had given pause to the idea that role models right here in our community could be a resource for our future thinkers and doers.

Proactive events that advance girls' and women's awareness and understanding of their strong STEM discipline potential must occur within and outside of elementary, middle, and high schools, and to a greater extent, the years. A heightened awareness of stereotype threat and the mitigating role of a growth mindset must also become a routine component of teacher preparation and continuing professional development. Research on the impact of such programs as WIMSY must be conducted in a way that answers questions about the effectiveness and benefits of such positive programs.

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