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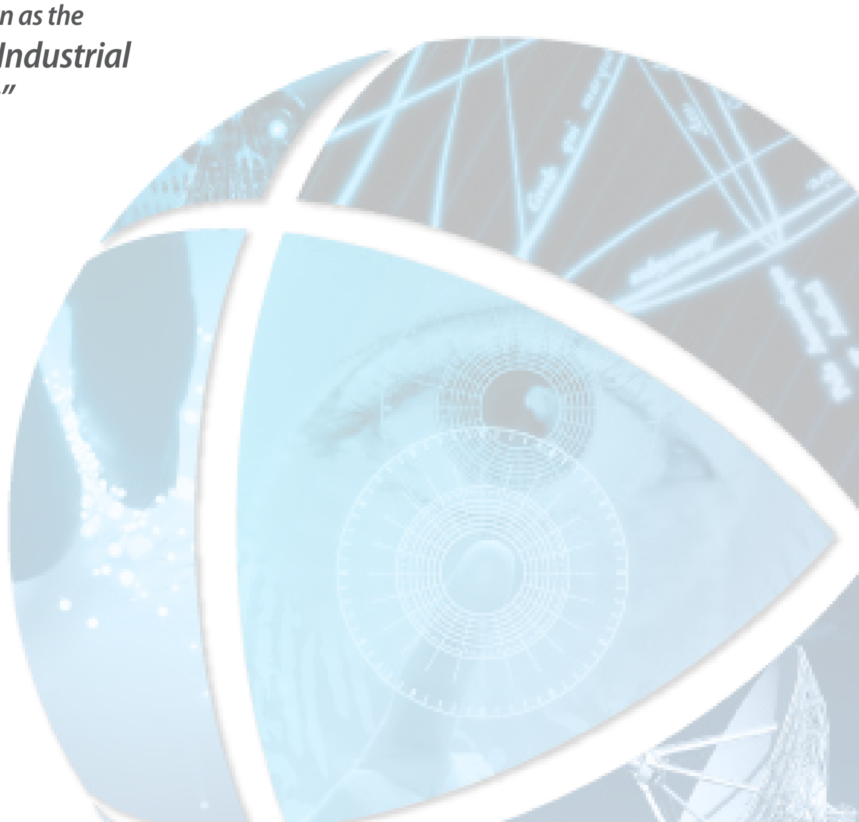

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Different, Not Deficient: The Challenges Women Face in STEM Fields

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ABSTRACT

Despite the increase in female labor force participation, women remain substantially underrepresented in most science, technology, engineering, and math (STEM) fields. The small number of women in these and similar fields have variously been attributed to discrimination and differences in ability or choice (Rosenbloom, 2008).

The reason women have made such a slow entrance into STEM fields remains controversial. Former Harvard President Larry Summers speculated at a January 2005 conference on the possibility that differences in the distribution of ability among men and women might play some role in the small numbers of women at the highest levels in science. Women face differential barriers to entry into the technical and scientific fields that discourage their participation. If these barriers were eliminated women and men would enter technical occupations in equal numbers (Rosenbloom, 2008).

This research is based on the theory that women are different, not deficient in their ability to succeed in STEM related careers. The authors of this paper believe that stereotypes are impacting women's decisions to pursue and remain in STEM career fields, including stereotypes relative to abilities, societal influences, and workplace environments. Included in this study are discussions and recommendations targeted toward parents, educators, and industry to reduce the effects of stereotypes as they relate to the challenges that women face in STEM career fields.

INTRODUCTION

"The experience of women, whether they like to admit it or not, is that being viewed as different has meant being viewed as deficient or deviant" (Rosener, 1995, p. 105). Images, symbols and systems of belief have continued to link science, technology, engineering and math (STEM) with men and masculinity, and separate it from women and femininity. Together these symbols and systems have operated to create a sense that such divisions are natural (Acker, 1999), with men the standard group and women the nonstandard or other group who are different from the norm (Fox, 2006).

Although STEM related fields carry a masculine gender identity, women are no strangers to these professions. According to anthropologist Sally Slocum in Nelson's 2004 article, women were probably its first inventors. As early as the 1900s, a significant population of America's urban centers was made up of single women who worked in high tech industries—primarily in garment, textile, and food processing factories (Nelson, 2004). The onset of World War II brought a critical shortage of male labor and the only solution was for women to fill men's jobs. The surprise for all was that these women were competent and fully able to fulfill the requirements of these positions (Bostic, 1999). Yet definitions of technology, historically and currently, are often male–centered and exclude women's areas of expertise. In fact, the garment and textile industries were built mainly on the inventions of women and are the largest employers of women outside of farm work (Nelson, 2004).

Despite the fact that women are capable and have a historical track record for contributing to STEM related fields, the number of women represented in the STEM fields remains dauntingly low. Today, women make up nearly 47% of the labor force; however, less than 20% of most engineering professionals are female, 27% are scientists and 31% chemists (Rosenbloom, 2008). In 2009, women employed in mathematical and computer science industries declined to 24.7%, down from 31% (NSF, 2010). In addition, women in STEM fields are less likely than men to be employed in the industrial sector and far less likely than men to hold management, senior management or corporate officer roles.

WHY WE NEED MORE WOMEN IN TECHNOLOGY AND SCIENCE?

Grover Cleveland, the 22nd (and also the 24th) President of our country is famously attributed having said: "Sensible and responsible women do not want to vote. The relative positions to be assumed by man and woman in the working out of our civilization were assigned long ago by a higher intelligence than ours" (Bard, 1985, p.79). Fast forward 120 years later and a Reuter poll of more than 24,000 adults in 23 countries released on the eve of International Women's Day 2010, found that one in four adults globally were most likely to agree that a woman's place is in the home (Reuters, 2010). There is an entrenched sentiment about women's role in society that is shifting at a glacial pace.

During one of the author's senior seminar classes on women in technology, a female student wanted to know: "Why does it matter? So girls are not interested in technology. What is wrong with that?" There are two issues with that basic question: First, it assumes that all girls are a certain way—that there is a right way to be and everything else is

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Dr. Kenney and Ms. McGee would like to acknowledge the contributions made by the late Dr. Kaninika Bhatnagar to our research titled "Different, Not Deficient—Challenges Women Face in Stem Fields". Kaninika was a key contributor in helping define the research, review the literature, and draw conclusions based on the meta-analysis. She had a tenacious spirit in researching, applied advanced critical thinking, and was a true team player. We are appreciative of her contributions and will miss her friendship and presence in our future research projects.

wrong. The other and perhaps more damaging assumption is the implied ignorance about a world driven by technology, where by relinquishing science, technology, engineering and math, women as a group may be forfeiting their "driver's seat" role in the critical engine of our civilization.

Jobs in the new economy are increasingly technology-oriented. According to a study from the University of California-San Diego, careers in mobile and healthcare technologies are the fastest growing fields for undergraduates in the current economic slump (Reichmeier, 2010). Summers, the Director of the National Economic Council underlines the importance of information technology for 21st century jobs: "We live in a world where skilled workers are increasingly mobile, where ideas are readily transmitted across international boundaries…. The information technology revolution is redefining infrastructure" (Summers, 2010, p.3).

It does matter if more women enter the STEM fields, and the reasons at the most fundamental level are twofold. From an economical perspective, *technology is good for women*, in terms of more and higher paying jobs and advancement opportunities. However, from the perspective of feminist science, the argument can be reversed: *Women are good for technology*. Women bring a rich diversity of experience and perspectives that are invaluable, and the incidence of fewer women in higher echelons of technology jobs creates a detrimental void of outlooks and sensitivity. There is a third consideration as well. Arguably women represent the family and children in all societies. Thus, educating women goes beyond the individual; instead it becomes a strategy to lift up entire families in terms of economic and cultural gain. Women represent a key sector of the workforce and a viable market to help close the gap in the STEM work force labor shortage.

STATEMENT OF THE PROBLEM

Women are capable and competent, yet remain underrepresented in STEM related fields. The problem is not about ability or deficiency, it is the socio-cultural phenomena of stereotypes—stereotypes of abilities, societal influences, and workplace environments.

LITERATURE REVIEW AND DISCUSSION

A report by the National Academy of Science (NAS) revealed that in order for the United States to maintain its competitive edge in an ever changing technologically advanced global community there is a need to: (1) Recognize that the STEM related workforce is aging in the United States; and (2) Realize that there are not enough new STEM workers entering the field to replace those retiring workers (2007). Consequently, the United States should take action to widen the pipeline of students prepared to pursue STEM related careers (NAS, 2007). But in order for this to happen, the stereotypical view of women must be recognized and altered – not an easy challenge.

Society has attached stereotypes to women that can be observed on a daily basis, yet most individuals fail to admit to themselves and others that stereotypes have any type of influence upon their judgments (Lippman, 1922; Valian, 1998). Neglect of ownership in this instance has had a crippling effect on how women are perceived in STEM fields. When ownership does not occur an individual or group is not completely able to admit that a change in their behavior or the behavior of an institution is needed. Through understanding of stereotypes, individual reactions to debunked stereotypes may become less difficult and the automatic gender biases reduced, resulting in positive reception to the idea of women filling technology, science, math, and engineering occupations.

Stereotypes and Ability

Eliminating stereotypes early in life through various means may help balance gender inequality. Society has started the initial process of educating young children in various ways. Recent data reveals that girls ranging from elementary to high school age are just as prepared as males to pursue careers in the STEM fields (Hill, Corbett and St. Rose, 2010), but the need for encouragement to actually take that step to pursue the career may still be absent. Females are presented with a number of stereotypes they need to overcome during early education.

One stereotype young girls face is being regarded as unskilled in STEM fields. Because of stereotypes, society and females themselves believe their skill sets live in the social aspects of society (Wender, 2005), It is difficult for girls who are presented with these stereotypes at an influential age to look past the roles society has assigned to them, and work toward a career that defies that image. According to Wender (2005), "a woman is regarded and regards herself as preferring social relationships. Social roles are distinguished through behavioral expectations that society assigns as norms to members of a certain group" (p. 45).

Although many women enter college with the ability to succeed in STEM fields, a smaller percentage of women than men choose STEM related majors (NSB, 2000). One theory attempting to explain why there are so few women in STEM fields revealed a persistently large gender gap between boys' and girls' spatial skills relative to mental rotation of objects, with men consistently outscoring women (Linn and Petersen, 1985). Another possible explanation by Lynn and Irwing (2004), which has come under scrutiny, is that men are biologically better suited for STEM professions than women since men outperform women on high stakes tests. A later report published by the Institute of Education Sciences (IES, 2007) stated that the differences in men and women's performances in STEM areas are subtle. Some issues the IES pointed out convey that although boys and girls select similar math course loads, boys garnered slightly more science credits than girls. Additionally, girls outperformed boys in math courses while boys typically outperformed girls on high stakes math exams such as the Scholastic Assessment Test (SAT), thus raising the issue of competition. The IES report also pointed out that although girls bested the boys in verbal skills, use of memory, and perceptual speed, boys outperformed girls in areas related to visualization and spatial orientation, which are considered essential for success in science and engineering (IES, 2007). Despite evidence of varying mathematical and spatial skills abilities, some studies offered other explanations for the STEM gender gap. Sorby (2009) reported data that revealed girls could improve 3D spatial visualization skills in a short period of time with training, and that girls who received training were less likely to drop out of engineering than girls who did not.

Reports focusing on varying ability levels between males and females are challenged by research, which reveals that environmental and socio cultural factors could affect the numbers of women in STEM. Spencer, Steele and Quinn (1999) found evidence that demonstrated that women and men performed almost identically on math tests when the "stereotype threat" or impression that men outperform women was removed (Spencer, Steele and Quinn, 1999). Another study by Goode, Aronson and Inzlicht (2003) confirmed these findings, when their research discovered that reassuring students that learning is a process and students should not internalize academic difficulties might minimize the effects of a stereotype threat. Students in the test group earned significantly higher standardized math scores than students in the control group, which implies that removing stereotype threats can help some students (females and minorities) minimize related test anxiety. A similar study conducted by Johns, Smader and Martens (2005) revealed that by informing women and minorities of the potential effects of stereotype threat, the effect can be minimized on standardized test takers.

Stereotypes and Societal Influences

Self-assessment and cultural beliefs about career choice appropriateness could account for the disproportionally low numbers of women in STEM careers. Women's avoidance of STEM careers is believed to be the effect of societal beliefs about math and gender influences on students' decision to choose a career (Correll, 2001). Correll's study revealed students' self-assessment and consideration of self-competence affected decisions to select a major. This research revealed that among male and female students with similar math achievement scores, boys' self-assessment of math skills were higher than girls' (of similar abilities) self-assessment. Consequently boys were more likely to enroll in higher-level math courses, such as calculus, because they considered themselves to be better in math although the scores were equivalent. When the math self-assessment levels were controlled, the gender gaps in college major choices were reduced. A revealing aspect of Correll's study confirmed that the higher a student assessed his/her ability in math, the greater likelihood that individual would pursue a STEM career. Correll also pointed out that even for those who did not agree with the stereotypes, just being aware that others held those opinions could affect a student's outcome. The fact that STEM careers are viewed as male dominated professions may increase men's tendency to choose these careers and lower women's interest in these fields. This research implies that parents and teachers can reduce the impact of these societal influences on student's career choices by telling students that girls and boys can be equally successful in STEM professions (Correll, 2001). The IES report (2007) reiterated Correll's claim by pointing out that girls tend to demonstrate lower confidence levels in their ability to do math and showed less interest in math and science careers than boys.

Helwig's longitudinal study of gender role stereotypes (Helwig, 1998) and the American Society for Quality suggested that the gender gap in STEM fields persists because of a lack of interest among females. The ASQ survey revealed that although 85% of students polled were not interested in becoming engineers, they found significantly more boys than girls were interested in becoming engineers. Girls believed their parents wanted them to become doctors, lawyers or even actresses, but few were interested in engineering (ASQ, 2009). Interestingly women's self-rating of ability had lowered by their sophomore year of college whereas men's self-rating of intelligence remained unchanged (York, 2008). The effects of math and spatial ability coupled with low levels of confidence and societal influences could culminate to discourage women from pursuing STEM careers.

Stereotypes and the Workplace

The traditional male dominated, change resistant STEM workforce has great influence on whether women believe opportunities are available to them. Men control most of the professional areas at the highest levels in these fields, and rarely desire to change the institutions' hierarchy or structure that is dictated by stereotypes (Valian, 1998). This includes how academic institutions and professional entities in the workforce are structured—men at the top and women filling lower positions. Many times women make their entrance into the STEM fields only because of the assistance of a close male friend (Bart, 2000). And the women who find a way into the traditional male-dominated workforce in technology and engineering fields are greeted with more obstacles to overcome.

Since society places the role of primary caregiver on women, it is expected that their chosen profession will not affect their ability to parent nor distract them from their "real" job of being a mother. Society, even in the 21st Century places distinct roles on women—they are either "work oriented or family oriented" but not both (Dillaway and Paré, 2008). Stereotypes regarding gender and family roles are strictly perceived on how women should act and be relative to family and work with few exceptions (Xie and Shauman, 2003). Surprisingly to some is that society's view of a mother's role is nearly identical to what it was decades ago when a mother's role was to stay at home to be with her family. A 21st Century woman who chooses to pursue a career is quickly labeled as a distracted mother, instead of a good mother. Women are viewed negatively if they miss work to care for a child and believe they cannot let their home lives affect their work lives if they want to stay on the same playing field as their male co-workers. When women experience an extreme amount of pressure and stress on the job, which can easily occur when working to discredit stereotypes, many women choose new careers that are more open to the idea of women as professionals. Choosing new careers perpetuates the stereotype that women are not "cut out" for jobs in the STEM fields (Dillaway and Paré, 2008).

Nosek, Smyth and Sriram (2009) examined the effect of sociocultural bias against women in the workplace and found that there are explicit and implicit forms of bias women may encounter on the job. Although the explicit bias, such as policies that discriminate, may be less prevalent, the implicit biases such as attitudes and assumptions, may make the workplace less inviting. Through their research, Nosek, et al. (2009) discovered that even some people who support gender equity might subconsciously harbor implicit biases and negative gender stereotypes, since both men and women overwhelmingly associate men with the sciences and women with the arts. Nosek, et al. (2009) also reported that implicit gender bias, assumptions that men are superior, might result in higher scores for men and lower performance scores for women. These biased assumptions could have a significant impact in preventing females from pursuing STEM careers, could affect parental decisions to encourage or discourage girls from pursuing these careers, and could affect the hiring of females into STEM careers.

Similar findings regarding sociocultural impacts on women in STEM were reported by Heilman, Wallen, Fuchs and Tampkins (2004), who found that women encountered a penalty for success in male dominated fields. Their study revealed that women who were considered to be "successful" were also considered "unlikeable", and the fact that a person is liked or disliked could result in lower evaluations and fewer rewards from the organization. Heilman, et al. (2004) also pointed out that these sociocultural factors could be affecting gender gaps in STEM professions. Women, who were clearly as successful as men, were ranked as less likable resulting in a "double bind" which could affect women's ability to advance on the job. Socio-cultural factors such as the double bind could help explain some of the findings presented in the 2010 report on why there are so few women in STEM fields published by the American Association of University Women. The American Association of University Women found that women faculty and minorities were more likely to report dissatisfaction with the STEM workplace and more likely to leave than men. Some of the factors creating job dissatisfaction for these women included: (1) Family responsibilities; (2) Icy departmental climates; and (3) Feelings of isolation. The culmination of these environmental factors could help explain the higher attrition rates among female STEM faculty.

RECOMMENDATIONS

The authors have several suggestions about what can be done to reduce stereotypes against women and increase their representation in STEM related fields, beginning with parents, then educators, and finally the workplace.

Parents are the first line of defense

Parents are the first line of defense against the "stereotype threat", or the impression that men outperform women in science and technology (Spencer, Steele and Quinn, 1999; Goode, Aronson and Inzlicht, 2003). Arguably one of the first transference of social stereotypes occurs at home. It may be a passive process, where a child may absorb "lessons from the street" in the absence of any counter messages from home. It could also be more active, in that parents may be imparting their misguided albeit sincere beliefs, and proactively guiding their children in a gender-stereotypical fashion.

Both the former inaction and the latter biased but well meaning action may be countered by various parental strategies. They can instill basic values, set expectations, goals, and a culture of celebrating science and discovery in the family. Outdoor fun activities can be more inclusive, where Dad going fishing does not have to be an exclusive father and son event. Getting dirty, playing in the outdoors, collecting bugs and beetles, setting up a home computer, spending Saturday afternoon in the garage troubleshooting engine problems, can all be inclusive family events where girls participate and enjoy these events as much as boys.

In a survey of more than 150 high school students in the Midwest, researchers found that girls and boys who thought of technology as fun were more likely to select a technology major in college (Bhatnagar and Brake, 2010). Likes and dislikes are formed early in life and are often difficult to dislodge in later years. Inculcating a liking for science, technology, engineering and math in early years is a task that can be most effectively carried out by a parent.

For example, socializing habits and conventional upbringing can arguably expose boys to videogames, virtual or simulated navigation, as well as physical tinkering with assembling parts, troubleshooting gadgets, or hooking up cables. Following assembly instructions from a technical manual is an elementary lesson in 3-D cognition, where one must make sense of instructions and diagrams given in 2-dimensional space to put together a 3-dimensional object. It follows that a person engaged in mechanical activities will be exercising his or her spatial cognition skills more. Greater use leads to greater development, and thereby greater confidence, which in turn promotes more use. Parents can become the critical mediators in encouraging girls in activities such as action video games for instance, to ensure that expectations as well as opportunities are even and equitable for both boys and girls.

Educators can cement impressions

While parents can create and/or promote positive perceptions about science and technology subjects, it is fair to argue that experiences in school more often than not cement these impressions. It appears that our education system is doing everything right on paper. There is certainly little, if any, overt gender discrimination. Critics are even theorizing that reverse discrimination where boys are being left behind is taking place (Sax, 2007). The gender gap in self-confidence in math and sciences, and the resulting difference in self-assessment of math and science skills is critical to students selecting higher-level math courses (Correll, 2001; Bhatnagar and Brake, 2010).

Educators can address the issue of self-confidence in a variety of ways. One of the more extreme suggestions is moving toward a single-sex education model. Research has supported this model for both attitudinal and achievement variables (LePore and Warren, 1997) for the obvious benefit of being able to foster less stereotypical views of courses and occupations. Increasing the number of female mentors and female instructors for math and science subjects is a less aggressive and strongly recommended strategy for increasing girls' participation in math and science courses (Haag, 1998).

During lab activities it is often found that boys set up the experiment and take readings, while girls stand on the sidelines and take notes. A countering strategy suggested by the Institutes for Women in Trades, Technology, and Science (IWITTS) is to announce a "call time" to switch tasks (IWITTS, 2011). This can guarantee equal access to equipment handling for girls. The fact though, that such a relatively simple strategy can be applied, is an indication of the underlying deeper issues relevant to female students enrolled in science, technology, math and engineering courses.

Teachers may also try to relate subject matter to issues that more girls may be interested in. It may seem counter-intuitive at first glance, however, the fundamental principles of physics, math and technology may sometimes be communicated to students in overtly gendered ways. "Teaching principles of kinematics by using football analogies for instance, or momentum and projectile motion by rifle discharge sequence may unwittingly cause alienation and disinterest in an otherwise motivated and smart group of female students" (Bhatnagar, 2010, p.1). Learning, after all, occurs by internalization of examples in a relatable and familiar universe. When girls are presented concepts couched in unfamiliar terms, their dislike of example may transfer to a dislike of the subject itself.

The most valuable contributions educators can make toward encouraging girls to pursue STEM career fields is to instill greater degrees of self-confidence and self-esteem as it pertains to the related courses (Correll, 2001). Girls need reinforcement of self-confidence and a renewed purpose in pursuing science and technology, where their sense of self-efficacy is brought to match their actual scores. Educators can address this issue in a multitude of ways. More female mentors will help create tangible role models for female students. Counselors and teachers can actively engage in disrupting the myth of female ineptitude in science and technology. For instance, it has been reported that the grade point average of women who dropped out of an engineering program was identical to those who were retained (IWITTS, 2011). The issue was not ability but self-confidence, which is the single biggest predictor of success for women and girls in technology courses.

Schoolhouses and playgrounds can be hostile environments for many children for diverse reasons. It is critical for educators to create more open and equitable environments where both girls and boys receive encouragement and guidance to pursue careers in STEM.

Workplace and the culture factor

While the dynamics of family and education may tend to work outwards, it can be argued that a female friendly workplace is likely created by an inward focus on an inclusive work environment. The two-fold explicit and implicit socio-cultural bias against women in the workplace makes for difficult counter measures (Nosek, et al., 2009). Explicit bias in terms of discriminatory policies is most certainly on its way out in the United States, however, the implicit biases of learned behaviors, attitudes, and assumptions, are not only deep-rooted but also less visible. It is these implicit biases that are largely responsible for the still chilly climate in many STEM work environments. Recommendations for workplace enhancement must address the elusive yet all important culture factor. In the absence of any management directive, the culture of a workplace may often become a mixed bag of value systems and beliefs of its employees. Since the underlying beliefs and biases are usually entrenched, the only way these can be countered is by explicit policies and counter conventions spelled out as career-friendly, not pro-women or anti-men policies, and implemented in full force.

A wide variety of workplaces, both public and private, have instituted family- and career-friendly policies (State of Oregon, 2000; Gerten, 2011). These include flexible work options including job-share and telecommuting opportunities, paid and unpaid leave options, greater transparency in decision making, and flatter organization structures. Options for childcare, and services for seniors and the disabled, can form key aspects of a career-friendly workplace. Support groups for parents, an accepted tradition of working at home, and sensitivity of employers, co-workers, and supervisors to parental responsibilities, are all key to creating more career-friendly workplaces.

Although such policies help women navigate family and work, they may not lead to advancement or promotion or address other issues like icy departmental climates and feelings of isolation. A way to reduce the high attrition rate among female STEM professionals is to modify cultural climates where female employees feel empowered and supported (AAUW, 2010). A template for successful creation of a supportive climate can be found in the private sector, especially among high-tech companies. Hill, et al. (2003) reported that 35% of fathers and 49% of mothers at IBM have had flexible work schedules, while 82% of fathers and 89% of mothers intend to do so in the future. Other key policies that can be put in place to make workplace more welcoming for women are intra-office social networking tools to encourage women to become more involved, rather than the “good old boys” water cooler networks, and flexible work schedules, which is an effective way to create a welcoming workplace. A well-instituted buddy system can also go a long way in providing support, and mentoring through informal networks for newcomers.

Creating a strong work culture of inclusiveness, encouraging differences, new ideas, independent opinions, and risk-taking, are all strategies to inculcate a climate that not only welcomes diversity, but also may be great for innovation and eventually the bottom-line. The goal is to transform deep-seated beliefs, values, and cultures put in place over centuries of male hegemony. Often these assumptions and beliefs are so much a part of us, that they become invisible. The problem of gender gap in STEM must address and cut away at these unspoken assumptions, which paralyze our minds, and blind us to opportunities, as well as the sheer joy of discovery.

LIMITATIONS

The authors of this paper studied existing literature and employed meta-analysis as an analytical technique designed to summarize the results of multiple studies. By combining multiple studies, the sample size was increased and thus the power to study similarities and differences. In this study the sample size was deemed adequate to ensure a representative distribution of the population and to be considered representative of groups of people to whom results were generalized. However, the assumption that a perspective paper represents the final and accurate viewpoint in an area of research is not defensible and may be considered a limitation by some.

One might also take into account that a meta-analysis study reflects only what has been published, hence published results are biased high and that could be considered a limitation. Ultimately its value depends on the researchers making some qualitative-type contextualization and assessment of the objective data. A final limitation to consider is that the inclusion or exclusion of research for a meta-analysis study may be impacted by the authors’ unintentional biases about the underrepresentation of women in STEM related fields.

CONCLUSION

STEM fields are considered crucial to the United State’s economic growth and are expanding rapidly (Fassinger and Asay, 2006). Science and technology form the frontier outposts of our civilization. In fact, NSF (2010) identified addressing the adequacy of the supply of scientists, engineers, and science teachers as one of the top 10 priorities of the early 21st century. However, in order to make STEM fields equitable and beneficial for everyone, it is critical to engage more girls and women to help shape the future. The encouraging news is that women’s representation in the STEM workforce has improved in recent decades. Women made up 1 percent of engineers in 1960 and increased to 11 percent of engineers by 2000 (AAUW, 2010). Overall, progress has been made, but a 10 percent increase in more than 50 years is not sufficient.

Transforming the culture of science, technology, engineering and math fields is the key to narrowing the gender gap. It will not be enough to simply assimilate women into the existing environments of STEM careers; action must be taken to broaden the cultural norms of these professions. Changing the future depends upon recognizing the problem, and the problem is not about ability or deficiency, it is the socio-cultural phenomena of stereotypes—stereotypes of abilities, societal influences, and workplace environments.

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