Analyzing Self-Confidence within STEM: A Literature Review

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***Abstract**: There is a question that is still plaguing the United States within education and the workforce. That question is: why women are still underrepresented within STEM. Research within this document looks into the documentation of self-confidence within K-12 STEM and STEM-related majors. Looking into the future, STEM jobs are on the rise and building a high-quality field requires a deeper understanding in what is causing the lack of representation of women in the field of STEM. Investigating the research can help build a stronger understanding of the lack of numbers of females in the STEM fields.*

Confidence level is defined by the Oxford Dictionary as "The feeling or belief that one can have faith in or rely on someone or something" (Oxford Dictionary, 2018). Litzler, Samuelson, and Lorah (2014) define self–confidence as "an individual's general belief that he or she has the ability to produce results, accomplish goals, or perform tasks competently, and perceptions of self-confidence can vary by domain." SciGirls (2016) point out that research over the years have found that girls lose confidence levels within STEM (Science, Technology, Engineering, and Mathematics) for a variety of reasons. Where does STEM confidence start forming in females? Stoilescu and McDougall (2011) indicate that females in elementary school start off with a lack of confidence in using software because software is often thought of as constructed for the male student (p. 313).

Murphy and Manini- Samuelson (2012) point out that a lot of research has been published exploring STEM and middle school and high school students, but they feel that STEM needs to be stressed at an elementary level (p. 18). Teachers collaborating with STEM can create an early intervention for all students and build interest and confidence levels for students (Murphy & Manini- Samuelson, 2012, p. 18). Marra, Rodgers, Shen, and Bogue (2012) state in 2012 that the United States has already seen a 35 percent drop in engineering from 2002 (p. 6). SciGirls (2012) point out that the low confidence level and interest in STEM can be linked to female's negative self-perception (p. 6). Girl Scouts Research Institute (2012) stress that "African American and Hispanic girls have high interest in STEM, high confidence, and a strong work ethic, but have fewer supports, less exposure, and lower academic achievement than Caucasian girls."

Females in grades 4, 8, and 12 shows less confidence in math because they do not feel that they are as competent as their male counterparts; whereas in the area of math they might feel confident about science, and school can encourage confidence in STEM by encouraging a learning environment that allows questioning and reflective thinking (SciGirls, 2012, p. 8). Figure 1 shows that there is a decrease in interest and participation within STEM from 4th grade to entering the workforce, and it connects how, as time moves, the decreases for both males and females. It can be seen in Figure 1 also shows that the interest level decreases more for females within the field of STEM. While uninterested girls in STEM seem to have lower self-confidence and interest within STEM, girls who have high achievement, interest and self-confidence are more likely to get these attributes from knowing someone within the STEM field (Girl Scout Research Institute, 2012).

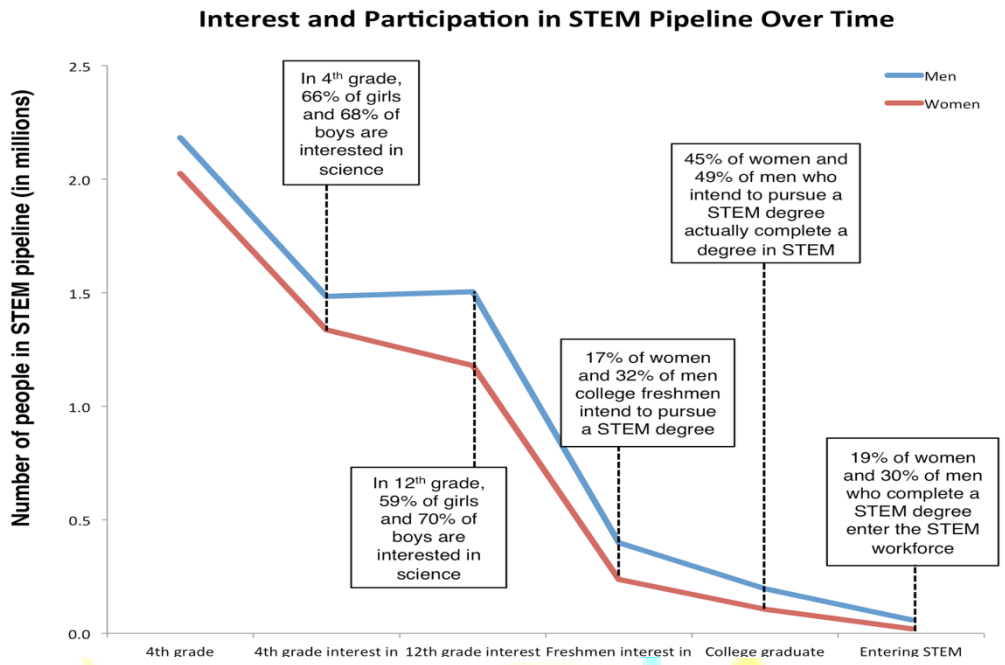

Figure 1.

Interest and participation in STEM from 4th grade to entering the workforce.From "Women 1.5 Times More Likely to Leave STEM Pipeline after Calculus Compared to Men: Lack of Mathematical Confidence a Potential Culprit," By J. Ellis, B.K. Fosdick, C. Rasmussen, 2016, *PLoS ONE, (11)*7. Copyright 2016 by Ellis et al.
SciGirls (2012) state the following:

"male students are 3 times more likely to be interested in STEM majors and careers, compared to female students". The difference in the gender gap within STEM can be tied back to the difference in girls' and boys' confidence level and interest level within STEM. It is imperative that authority figures encourage and build females' confidence levels within STEM before high school because in high school academic choice for college is being made (p. 6).

Contrary to SciGirls, high school can be a place where students can build their self-confidence within STEM because self-confidence in the maths and academic achievement within areas of STEM show a strong relationship (Moakler& Kim, 2014). Karimi and Saadatmand (2014) point out that academic achievement can be tied to three areas: the cognitive, the emotional, and psychological impact on anyone in an educational setting because it causes a change within the behavior of the student.

Falco and Summers (2017) discuss that in female high school students there seems to be a presence of the "confidence gap" that forms during adolescence stages of female education and seems to remain with the student into high school and high education decisions. Atherton (2015) stated that "female students from single gender schools outscored their male engineering counterparts, but benefited more from verbal encouragement, contextualization, same gender problem solving groups, and same gender classroom dynamics". Falco and Summers (2014) stress that even higher-achieving females still report self-confidence issues within STEM, and for all students that are underrepresented within STEM, negative stereotypes with the field and STEM classrooms have impact on a student's confidence in their abilities and their performance; this could bring about a lower desire to pursue a STEM career.

Self-confidence directly affects how a student makes choices, drives motivation and persistence, and shows student vulnerability within a subject (Karimi and Saadatmand 2014). Pulford, Woodward, and Taylor (2018) state that students have a certain impression about their achievement, which may not connect with their academic abilities of gender stereotypes whereas they may have different types of academic confidence. Threats, especially those committed by teachers and parents, can have a large influence on female self-confidence and their desire to pursue STEM within all levels of education. Not all is lost when it comes to building a strong well-represented workforce within STEM; however specially designed instruction geared

towards females and other underrepresented people within STEM may have an impact on their views of STEM, and will give them the opportunity to enter a career path that they may have not originally thought as an option (Falco and Summers, 2014).

For females and other underrepresented students, negative stereotypes lower self-assessments of STEM-related abilities as well as their performance in STEM tasks, ultimately compromising STEM educational and occupational aspirations (Moaker& Kim, 2014). Pulford et al. (2018) stress that gender can have an effect on academic self-confidence, and that females report that they have less academic self-confidence than men. Jones (2010) discusses work completed by Carol Dweck, and states that there are two types of student mindsets to consider the "growth mindset" and the "fixed mindset". Pulford et al. (2018) point out that self-confidence has shown a connection math and English and achievement within the classroom. They are both very different but valuable viewpoints.

Jones (2010) continues by explaining that "growth mindset" looks at intelligence as a quality that can continue to grow over time through hard work and challenging task completion, while a "fixed mindset," views intelligence as something that cannot be changed over time; if students have the "fixed mindset" there is more of a chance that they will see a decrease within their self-confidence when they are placed in challenging situations. Moaker and Kim (2014) seem to agree by stressing that students with higher STEM classes, like mathematics, often have higher self-efficacy which in turn lowers their anxiety, and they report a self-confident mindset. The girls that do show an interest in STEM and persevere past the stereotypes feel that they are smart enough to be in a STEM career when they grow up, and 71 percent of girls in STEM at an early age have a high self-confidence about their abilities compared to other girls (Girl Scout Research Institute, 2012).

It is not a secret that men and women have different percepts of their confidence levels within STEM, particularly the maths, but is this perception a key influence in why female students drop STEM related classes at the university level (Ellis et al., 2016)?Marra et al. (2012) found within their study of 113 undergraduate students that poor retention to engineering majors consists of overly challenging academic matter, and a lack of belonging to the major (p. 23).Ellis et al. (2016) research found that self-confidence is a factor that leads females to change or drop out of high mathematic classes, which can lead to a major change from a STEM major to non-STEM major.

Huziak-Clark, Sondergeld, Van Staaden, Knaggs, and Bullerjahn, (2015) noted in their research findings that there was not a significant difference between males and females when it came to their positions within their STEM major, but women did discuss their main focuses (i.e. Personal experience, feelings of security), which was different from the general responses of their male counterparts (p. 234). Litzler and Young (2012) state that females in STEM majors may be at a disadvantage as they enter the male-dominated environment which conflicts with their own personal identity (p. 320). On average, 40 percent of students who entered college as engineering majors, changed their major by their second year, with females representing the bottom end of endurance (Litzler& Young, 2012, p. 320).

Grunspan, Eddy, Brownell, Wiggins, Crowe, and Goodreau (2016) state social interaction can have an influence on female's self-confidence, and females felt this more strongly in a male-dominated field. Litlzer et al. (2014) agrees that self-confidence affects STEM majors, in particular, engineering majors, because females generally state that self-confidence within the major is one of the reasons why they choose to change majors. The overall 25 percent is split up between the different disciplines within STEM and women only representing 14 percent of females are in the engineering career field (Ellis et al., 2016).

Grunspan et al. (2016) stress that positive interaction with teachers and faculty members can help increase students' self-confidence within the classroom. Litzler et al. (2014) point out that there should be more to research within the area of self-confidence with the realm of STEM in order to understand the student experience within the classroom and to be able to build STEM confidence within multiple genders and races. "STEM is consistently "losing" to other career options, such as teaching, and social services" (Girl Scout Research Institute, 2012).

One needs to ask: does self-confidence play a role in what major women choose when selecting a course of study due to the gap seen in STEM over the years? Grunspan et al. (2016) point out that many studies have found that females within STEM do need to have a sense of belonging in their fields and the family unit initiates the confidence that females can succeed within STEM; in fact, females choose to leave a major due to a

lower self confidence in their ability more often compared to their male counterparts. The low interest seen in girls may play off the concept that girls do bad in math or have low confidence in their abilities, causing girls to investigate more verbally related careers (Girl Scout Research Institute, 2012). Moakler and Kim (2014), through their research, found that female students had lower outcome confidence toward STEM careers and majors compared to their male counterparts, and they found a correlation between female students with low self-confidence in the math fields and low STEM major choices.

Cech, Rubineau, Silbey, and Seron, (2011) define professional role confidence as, "individuals' confidence in their ability to fulfill the expected role, competencies, and identify features of a successful member of their profession" (p. 642). Jones (2010) discusses how that females tend to not consider careers in STEM because of the following: "particular social, cultural, educational, and self-confidence factors." Within careers that appear to be male-dominated such as engineering, it is more of a challenge for females to establish professional role confidence because men appear to fit in better within the career setting whereas women tend to be left out (Cech et al. 2011; Litzler et. al 2014). In order to build professional confidence within any field requires encouragement of one's personal confidence, and females and males establish contrasting professional role confidence, especially in a career role that is dominated by the opposite gender (Cech et al., 2011, p. 642).

Grunspan et al. (2016) point out that when a person of either gender who is supported by a significant person within the field of employment or study will be able to see an increased in performance and an increase in confidence while a student not receiving confidence affirming experiences can experience a decrease in their performance and confidence levels. Litzler et. al (2014) stresses that there is a connection between self-confidence and self-efficacy that cannot be ignored because self-efficacy is associated with self-confidence. Because of how self-confidence and self-efficacy impact each other, both of these elements present themselves as an important aspect for females with the roles of academic and career development within STEM. The lower confidence in their own ideas can also cause women to feel less confident in their own abilities. If girls' self-confidence rises within STEM, girls will be able to see that careers within the STEM field are possible; this self-confidence will assist them in choosing and persevering within STEM careers and majors (Girl Scout Research Institute, 2012).

Overall, building equal self-confidence can assist all students pursuing a major, career, or subject that peaks their interest. Dubriwny, Pritchett, Hardesty, and Hellman (2016) stress that increasing the number of students entering the STEM field is a priority and increasing self-confidence within students can assist with that endeavor by building interest endurance and the ability to achieve positive results within STEM classes and content areas. Girls can feel confident with their abilities in STEM and if they feel interest, ability, and confidence within STEM, they will be able to believe in their abilities and step up to challenges (Girl Scout Research Institute, 2012).

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