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Factors Contributing to the Gender Gap in STEM Education

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Abstract

Women remain underrepresented in science, technology, engineering, and mathematics (STEM) occupations. In 2018, women made up 50% of the college-educated workforce, while making up only 28% of those working in science and engineering fields. This is of interest as women at the postsecondary level and girls in first through 12th grade currently achieve grades equal to or above their male counterparts in math and science education. This literature review explores many factors found to contribute to the gender gap in STEM education. These factors include girls' lack of belief in their ability, the lower level of interest and utility value for STEM content areas, and prevailing stereotypes that boys are better at math and science than girls which have contributed to the STEM gender gap in different and important ways such as girls' self-esteem, achievement, and intentions to pursue STEM classes and careers. Understanding these different factors supports interventions and strategies that will mitigate their effects and encourage girls and women to continue and succeed in STEM education.

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Chapter I: Introduction

The United States Bureau of Labor and Statistics has reported that science, technology, engineering, and mathematics (STEM) occupations are projected to grow over two times faster than any other occupation over the course of the next decade. These jobs are playing an increasingly important role in the economic growth of the United States as well as the overall globalization of the world (Zilberman & Ice, 2021). As was recognized by Goldin et al. (2006), the level of women's education has increased over recent decades and yet it is an ongoing concern that women are still underrepresented in the workforce of STEM careers. According to the National Science Foundation (2018), women made up 50% of the college-educated workforce, while making up only 28% of those working in science and engineering fields. Of that 28% working in science and engineering, a larger portion of women work in the social sciences and life sciences, while women remain much more underrepresented in engineering, physical sciences, and computer and mathematical sciences.

So, why are there fewer women in STEM careers? Historically, there have been gendered stereotypes that women are less capable in STEM content areas beginning in the early years of education. This opinion has persisted in society and is often held by parents and teachers (Beilock et al., 2010; Master & Meltzoff, 2020; Selimbegovic et al., 2019). However, research conducted on students from second to 11th grade in 2008 found that mathematical performance between girls and boys in the general population is inconsequential. Through continued research, any validity to the stereotype that boys are better at STEM than girls has slowly eroded (Hyde et al., 2008; Hyde, 2016). Rather, other non-aptitude-related factors appear to affect girls' success and enrollment in STEM classes and majors (Ahmed & Mudrey, 2019; Cvencek et al., 2011; Selimbegovic et al., 2019). Motivational components such as girls' belief in their ability, interest, task value, and the presence of prevalent stereotypes have also heavily influenced girls' achievement, participation and investment in STEM.

Even as girls and boys within various age groups are performing academically similarly in math and science, girls remain under confident in their ability with a lower level of self-efficacy compared to their male counterparts (Lloyd et al., 2005). This is present even at the collegiate level of education when women who are outperforming men and receiving better grades in STEM classes (Marshman et al., 2018). Since self-efficacy is a predictor of a student's success, this has major ramifications for girls and women (Aurah, 2013; Britner & Pajares, 2006). The lower level of belief in ability has the potential to begin a downward spiral impacting not only immediate performance on tests or in classes, but also the potential to have long lasting achievement implications and impact participation in STEM. If girls have a lower level of confidence, they may perform poorly; and their poor performance may lower their level of self-efficacy causing them to choose to focus on other classes or careers instead.

In addition to self-efficacy, girls' task value in STEM may also affect their achievement and their willingness to participate in STEM (Eccles, 2009). According to the expectancy value theory, task value includes both the interest a person has for a topic as well the value they place on the topic, also known as utility value. Researchers found that young girls demonstrated a lower level of interest in STEM and their interest continued to decrease throughout middle and high school (Maltese & Cooper, 2017; Sadler et al., 2012). This is concerning as it directly correlated to their decision to pursue STEM classes and careers further as well as potentially influenced their success in these content areas (Grigg et al., 2018; Harackiewicz, et al., 2008; Köller et al., 2001).

Further, girls reported that they value STEM less than other content areas (Wang et al., 2015). Research further revealed that a student’s perceived usefulness of STEM predicted their desire to continue in STEM as well as their achievement. This was found to be especially true for girls (Ahmed & Mudrey, 2018; Brown et al., 2016; Eccles, 2009). Therefore, those who value STEM less were reported to have lower levels of performance and were less likely to pursue a STEM career than men.

In addition to self-efficacy, interest, and task value, stereotypes and social support were major factors in the gender STEM gap (Cvencek et al., 2011; Stake, 2006). Stereotypes held by parents and teachers affected the decisions they made and the way in which they interact with their children and students; this included buying boys more STEM-related toys than girls, spending more time explaining scientific concepts to their sons, and underestimating girls’ math ability (Bhanot & Javonovic, 2005; Crowley et al., 2001; Jacobs et al., 2005). In fact, parents and teachers may pass their stereotyped belief that boys are better at STEM than girls on to children who may be as young as first grade. The influence exhibited by parents and teachers, as well as the impact of peers, has correlated with student motivation and success in STEM as well as student’s decision to pursue STEM careers in the future (Bleeker & Jacobs, 2004; Lavy & Sand, 2018; Leaper et al., 2012; Wang & Eccles, 2012).

Definitions of Terms

The following terms are defined for the purpose of this paper.

Ability Belief: Ability belief is used by Master and Meltzoff (2020) and refers to a student's belief in their ability to succeed in a specific content domain or task. It includes several types of beliefs used in previous research such as self-efficacy, expectations of success, perceived competence, self-concept, or self-confidence.

Expectancy Value Model: The expectancy value model is a theory developed by Jacquelynne Eccles and colleagues (2009). It suggests that motivation is influenced by two sets of factors: a person's expectations/perceptions of their abilities and a person's personal subjective task values.

Girls: In this paper, the term girls refers to female students in first through 12th grade.

Mastery Experience: According to Bandura (1997) and social cognitive theory, mastery experience refers to a person's past experiences and performances. It is the most influential factor to a person's self-efficacy.

Self-Efficacy: Self-efficacy refers to a person's belief in their ability to succeed or accomplish a task (Bandura, 1997). In this paper, it is used specifically to understand girls' and women's beliefs about their abilities in STEM education.

Social Cognitive Theory: The social cognitive theory was developed by Albert Bandura (1997). It addresses both the environment and cognitive processes that interact and influence how humans learn and behave. This theory is applied to many areas of research. In this paper, self-efficacy, a specific subset of this theory, is explored as a contributing factor to the gender gap in STEM.

STEM: STEM is an acronym for Science, Technology, Engineering, and Mathematics.

Stereotype: A stereotype is a widely held and oversimplified belief about a person or thing.

Subjective Task Value: As developed by Eccles and colleagues (2009), subjective task value is one of the major components of the expectancy-value model. A person's motivation is influenced by the value they attach to various tasks and topics. Subjective task value can be further broken down into four parts: intrinsic interest, utility value, attainment value, and cost.

Utility Value: According to the expectancy value theory, utility value is one of the four parts of subjective task value. It refers to the value a person places on a specific task (Eccles, 2009).

Women: In this paper, the term women refers to female students in post-secondary education as well as females over the age of 20.

Research Question

The guiding question of this thesis is: based upon past and present research, what major factors contribute to the gender gap observed in science, technology, engineering, and mathematical education?

Chapter II: Literature Review

This chapter is comprised of article reviews addressing different factors and their contributions to the gender gap in STEM. Literature on each of these sections will be examined as they contribute to the disparity in women's participation and success in STEM education. First, there will be an examination of the gender differences in students' belief in their ability to succeed in STEM and the influence that belief has on student achievement. Next, the focus will shift to interest and its impact on the intention to pursue STEM education and careers. Following that will be a series of articles that concentrate on the role of utility value and the influence it has on student motivation. Last, the review includes STEM stereotypes and the social impacts of parents, teachers, and peers.

Ability Belief

With the rise in women's levels of achievement in STEM, researchers have turned to other factors that may contribute to the gender STEM gap (Huang, 2013; Lloyd et al., 2005; Marshman et al., 2018). Women's belief and perception of their own ability is one such factor. Ability belief encompasses concepts such as confidence, self-efficacy, self-concept, and one's expectation for success. According to Bandura's (1997) social cognitive theory, self-efficacy refers to a person's perception of their own ability to succeed or accomplish a task. Self-efficacy and women's belief in their ability, also called ability belief, can then influence women's activities, interests, and motivation towards tasks and careers (Bandura, 1997; Master & Meltzoff, 2020). Therefore, even if female and male students' rates of achievement are similar, disparities in these factors can contribute to the gender gap seen in STEM classes and careers.

This gender difference in perceived ability and confidence was initially uncovered by a study conducted by Lloyd et al. (2005). Using data from state standardized test scores, report card grades in mathematics, and tests to measure confidence in math, researchers studied 161 elementary and middle school students across five elementary schools and two middle schools. The first measurement, standardized test scores, revealed similar math performance for both girls and boys. The second measurement, report card grades, revealed that girls scored significantly higher than boys in mathematics classes (Lloyd et al., 2005). These two findings alone contradict past beliefs in women's lack of aptitude for mathematics and, despite the small sample size, these results supported previous research that the achievement gap between men and women was narrowing (Hyde et al., 2008).

However, the most compelling finding of the Lloyd et al. (2005) study pertains to the data on student math confidence. Despite the equal achievement on the standardized test and the higher achievement on mathematic report cards, girls tended to be less confident in math when compared to boys. Even with success in class and objectively higher levels of performance, girls were still less confident in their own abilities than boys. In this study in particular, female students' confidence in math did not mirror their achievement. This study did not indicate the cause of this discrepancy; however, it provided initial evidence for the disparity in girls' objective achievement in class and their self-confidence, especially in comparison to male students.

While the previous study only investigated fourth and seventh-grade students, this trend in lower female confidence persists in research in higher levels of education as well. Marshman et al. (2018) investigated the self-efficacy of students in two college-level physics courses in which 68% of those enrolled were in an engineering track, meaning a majority of those enrolled had chosen engineering as their major. Of those students who were enrolled, only 32% were female, demonstrating a gender gap in enrollment at the outset of these classes. Over 600 hundred students were surveyed and analyzed according to their final course grades. Even after controlling for performance differences, female physics students had significantly lower levels of self-efficacy than their male counterparts. By the end of the two-course physics sequence, female students in the highest performing group, those with As, were found to have a similar level of self-efficacy as the lowest-performing male students, those with Cs (Marshman et al. 2018). Similar to Lloyd et al. (2005), Marshman and colleagues found that females reported lower levels of ability than males, despite performing equal to or above the male students. In both studies, female students' perception of their ability to succeed did not reflect their objective performance. Female students appear to underestimate their STEM abilities, while male students possibly overestimate theirs.

Although Lloyd et al. (2005) and Marshman et al. (2018) studied two specific age groups, the gender disparity in self-efficacy can be seen across a wide range of literature. Huang (2013) conducted a meta-analysis of 187 studies that contained 247 independent studies; they specifically examined the relationship between gender and self-efficacy. The goal was to summarize research on these two factors not only in STEM, but also across multiple educational domains. The studies in the meta-analysis included journal articles, doctoral dissertations, master theses, and conference papers. By utilizing multiple studies and formats, this study aimed to quantify the appearance of varied results in gender differences in self-efficacy. Across all domains, males tended to have a slightly higher academic self-efficacy than females. However, this gender difference became more pronounced when looking at more specific moderators. Specifically, different content domains had a significant impact on the level of gender difference of self-efficacy. Math, as the two previous studies included, as well as computer science were specific content areas in which males tended to have a significantly higher level of self-efficacy than female students (Huang, 2013).

Additionally, Huang (2013) found that age also played an important part in the self-efficacy disparity. After examining studies by school levels (i.e., elementary school, middle school, high school, post-secondary, and those over 23 years old), a statistically significant effect size was found. In mathematics, the gap in self-efficacy appeared to increase with age and most clearly widened in high school and continued through college. While this finding laid the foundation for the increase of the gender disparity in STEM self-efficacy over time, further studies are needed to examine how women's ability beliefs evolve over the course of their educational careers. However, this study has implications for gender differences that may be a significant contributing factor to a mathematical and computer science gender gap. That is, if women have a lower perception of their ability in these domains, this lower belief may impact other academic areas as well.

Britner and Pajares (2006) found that belief in one's ability impacted academic areas when they suggested that self-efficacy and achievement have a more causal relationship than previous studies initially revealed. Their study examined whether self-efficacy made an independent contribution to students' science achievement. It looked at a small sample of middle school students and used self-report motivational data and students' final grades in a science class. Self-efficacy was the most consistent significant predictor of achievement for both girls and boys as indicated by their final science grade (Britner & Pajares, 2006).

Briner and Pajares' findings contrasted previous studies by demonstrating a causal relationship between a student's belief in their ability and their academic performance. Whereas previous studies (Lloyd et al., 2005; Marshman et al., 2018) showed high achievement contrasting with low self-efficacy for girls, this study suggested that the level of self-efficacy may instead predict students' grades and success in class. The process may work as part of a downward spiral in which students with low self-confidence consequently influence their ability to perform and succeed.

This inverse influence of low self-confidence on a student's ability to perform is further supported by a more recent study conducted by Aurah (2013). This study targeted the ways in which self-efficacy impacted the academic performance of older students. The study included over 1,000 students from 17 schools. It used a self-report questionnaire, ability tests, and problem-solving tests to analyze not only a student's belief in their own ability, but also other factors including background knowledge, metacognitive monitoring, and science problem-solving. The study aimed to determine the extent to which confidence and self-efficacy predicted a student's problem-solving ability and, therefore, their performance on a science test.

Using both quantitative data from the problem-solving test and qualitative data from the questionnaire as well as in-depth interviews, Aurah (2013) also found that self-efficacy was the strongest predictor of both male and female students' ability to problem solve. Students' perceived belief in their ability was found to be a more significant predictor of success than background knowledge on the subject. Accordingly, if self-efficacy can be used to predict success in problem-solving, it can then be extrapolated to predict not only a student's success on a specific test, but also a student's overall academic success and achievement in science. Therefore, if a gender discrepancy exists in STEM classes as demonstrated in previous studies, this difference in self-confidence has the potential to be a major contributing factor to the gender gap seen in STEM. Any detriment to a person's belief in their own ability may affect their success, and this discrepancy disproportionately affects girls and women.

Consequently, finding the sources of students' ability beliefs is important to understanding this disparity between the genders (Bandura, 1997). Several sources of self-efficacy may lead to this disproportionately lower level of confidence in women including their past experiences, vicarious experiences in the form of their observance of other students' performance, and social persuasion which includes people's experiences of verbal and nonverbal feedback from others. The most influential factor overall being a person's past experiences and past performances or what can be more generally classified as mastery experiences (Britner & Pajares, 2006). Examining the potential gender differences in these sources, in particular mastery experiences, may lead to the cause of the variation in confidence levels between men and women. This is especially pertinent when examining cases where current performance and achievement are negligible as women achieve equal to or better than men.

As mastery experience is often the most cited and influential source of self-efficacy, it is important to note the different ways in which male and female students may perceive their past experiences and how it has led to the gender discrepancy. Butz and Usher (2015) investigated the sources of confidence and self-efficacy in fourth through eighth-grade students and then further desegregated the data based on gender. The study sampled over 2,000 students across multiple elementary and middle schools. Computer surveys were administered utilizing both open-ended prompts and self-report measures of self-efficacy. According to the results of the study, overall mastery experience was one of the most frequently reported sources of self-efficacy as previous research found as well (Bandura, 1997; Britner & Pajares, 2006) This included students citing grades, hitting testing benchmarks, or getting a math question right as forms of mastery experience. In addition to this, social persuasion was also one of the most frequently reported sources of students. This finding was consistent across all grade levels from elementary to middle school. The differences in the proportion of these sources were found once the data was differentiated by gender. Girls' responses expressed more social persuasions than boys as well as more social comparisons to their peers (Butz & Usher, 2015). This suggested that girls' self-efficacy is influenced and sourced differently than boys' self-efficacy. Being aware of these differences can have implications for teachers, parents, and others who are working to address the STEM gender gap.

In a more recent study conducted by Zander et al. (2020), mastery experience was divided into three different indices: self-esteem, self-enhancement, and prior math grade. Traditionally, mastery experience had been measured based only on previous grades. In this study, Zander et al. (2020) included performance related self-esteem which strove to measure how students felt about their performance directly after taking the test as well as self-enhancement which was a representation of how students thought they performed on their test. This study analyzed 764 ninth-grade students using questionnaires and standardized math tests. While boys did outperform girls on the standardized test administered for this study, there were no differences in math grade between male and female students. In contrast, once again, females exhibited significantly lower levels of self-efficacy than their male counterparts supporting what previous research has also found.

With regard to the breakdown of mastery experience, girls reported a significantly lower level of self-enhancement and significantly lower levels of performance-related self-esteem than boys. While self-enhancement was a predictor of male students' self-efficacy, it was not for female students. Self-esteem, however, was a predictor of girls' self-efficacy (Zander et al., 2020). While girls academically achieved almost equal to boys, not only was girls' self-efficacy lower, but also girls' reported feeling worse about themselves following a performance test (low self-esteem). The cause of this low self-esteem and, therefore, low self-efficacy was not found in this study. However, it did narrow in on possible causes by breaking down the sources of self-efficacy which can enable further research and intervention to prevent this disparity in confidence between girls and boys.

Interest

Ability belief, specifically self-efficacy, may be a key component of the gender STEM gap; however, it is far from the only factor. Subjective task value is another key component of motivation as well (Eccles, 2009). According to the expectancy value model of achievement, subjective task value has multiple components including but not limited to intrinsic interest and utility value. People are motivated both by their expectation of success, which can be measured in a similar manner to Bandura's (1997) theory of self-efficacy and by the value they place on the topic or task (Eccles, 2009). These different components of interest and utility value play a crucial role in a person's motivation in achieving and pursuing classes and career choices within a specific domain.

Maltese and Cooper (2017) investigated the role of students' interest in STEM via a survey of over 7,000 individuals from both STEM and non-STEM fields. In this particular study, the researchers investigated the types of experiences and factors responsible for generating interest and choosing a major. The study had the participants, most of whom were at a postsecondary institution, reflect on their primary and secondary school careers. Interest and enjoyment were the top reasons individuals chose their particular major. Although this study included both STEM and nonSTEM majors, it demonstrated the influence of interest in a person's choices and intentions which can then be applied specifically to STEM fields. This supported Eccles (2009) theory that interest plays a large role in motivation and also highlights the role that interest plays in a person's career path. As a result, any gender difference in STEM interest has the potential to also impact the gender STEM gap.

This difference was observed in a study conducted by Tellhed et al. (2016), where over 1,000 senior high school students were given questionnaires to evaluate their interests. The participants were in university preparatory programs and spanned across 12 different school districts. Overall, female students reported a much lower interest in STEM majors than male students. In addition, this study also determined that self-efficacy strongly related to STEM interest. This appears to indicate that self-efficacy and interest are not completely separate factors, but rather have the potential to interplay. While this study highlighted the gender difference in STEM interest, it included data from only one static point in a student's school career (Tellhed et al., 2016). Further studies are needed to evaluate interest during a greater range of ages or over a greater scope of time in order to reveal the progression and changes of interest throughout a person's life and school career.

In fact, this variation in STEM interest across time and age groups has been well reported. Throughout elementary and high school, students' interests change and evolve (Frenzel et al., 2010; Sadler et al., 2012). Sadler et al. (2012) used surveys given to 6,000 students to examine their career intentions at both the start and end of high school. As a result, this study provided a broader look throughout the entirety of a student's four-year high school career. The results, segregated by gender, reported a more nuanced flow of students to and from STEM career intentions. Initially, at the beginning of high school, twice as many male students reported interest in a STEM career than their female counterparts. While the general portion of male students interested in STEM remained stable throughout high school, the percentage of interested female students decreased over the four years. Therefore, not only were fewer female students interested in STEM in the beginning, but also the disparity was exacerbated over the course of the four years of high school (Sadler et al., 2012). This study did have limitations, as it was conducted based on surveys of students in their first year of postsecondary school and may have been skewed due to data based on students' reflection on their past school experiences rather than present-day attitudes. Even so, it still remains valuable information as a representation of a students’ perceived path of STEM interest.

A similar trend was also present in a longitudinal study of earlier grades (Frenzel et al., 2010). This study included over 3,000 students and began when the participants were in fifth grade and extended through the students’ ninth-grade year. The students were surveyed at each grade-level; therefore, the data was representative of each student's interest at that given point in time rather than a reflection of the past. For this study, students’ interest in math, in particular, was the focus rather than STEM as a whole. It also investigated the effect gender had on interest throughout these grades. Over the course of those four years indicated, both male and female students lost interest in math between fifth and seventh grade. This is especially pertinent for girls as they already had lower levels of interest in math starting in fifth grade which then continued to decrease and remain lower than boys throughout the course of the study. Further examination of gender revealed that while boys’ interest trajectory leveled off after seventh grade, this was not the same for girls who appeared to continue to lose interest through ninth grade (Frenzel et al., 2010). This decrease of interest at lower grade levels was concerning.

This may be especially significant as the relationship between students’ interest in STEM and a students’ intent to pursue both STEM classes and careers has been established (Grigg et al., 2018; Harackiewicz et al., 2008; Köller et al., 2001). Analyzing students across 400 schools in grades six through 10, Grigg et al. (2018) investigated the relationship of self-efficacy, interest, intention, and achievement in the domain of math. Students completed a variety of different questionnaires to target each of these specific areas and this was done at two different points in the academic year in order to get two subsequent data points. First, interest significantly predicted math self-efficacy. Second, there was a significant relationship between math interest and math intentions. This relationship appeared to work in a reciprocal way. Initial math interest on the first set of questionnaires significantly predicted subsequent math intention on the second set of questionnaires, while math intention on the first data set significantly predicted subsequent interest level on the second set of data (Grigg et al. 2018).

While this study did not find that math interest significantly predicted math achievement, its findings on the impact of interest on self-efficacy have implications for academic achievement. As previously discussed in the last sections, self-efficacy has been found to be a factor of academic achievement and performance (Aurah, 2013; Britner & Pajares, 2006). Therefore, interest as a predictor of self-efficacy may indirectly have had an impact on achievement. The other key finding of this study demonstrates that interest and intention may work together to create a positive feedback loop that may guide a student's academic and career choices (Grigg et al. 2018).

This impact of interest on intention and possibly achievement is also supported by a study conducted by Köller et al. (2001) who studied over 600 students from seventh grade to 12th grade. Students' interest in 10th grade had a large impact on the course selections of those students in subsequent grades. Students who exhibited more interest in STEM were more likely to choose more advanced courses than those who exhibited less interest who then subsequently took basic level courses. In this study, students with more interest in STEM chose courses that would further deepen their understanding of the content. This was based on a review of the content of the advanced courses which had a higher number of lessons per week and more demanding classwork. This means students with more interest would choose more challenging courses that would inevitably push them further within that content. While this was not, in and of itself, a direct link between interest and achievement, course selection and in particular choosing more advanced courses, was a significant predictor of achievement in later grades (Köller et al., 2001).

In contrast, Harackiewicz et al. (2008) and Schiefele et al. (1992) found a more direct connection between interest and academic success. In the meta-analysis conducted in 1992, Schiefel et al. positively linked interest to academic achievement. While this study is not based on current data from the 21st century, it presents a broad perspective by including data from 18 different countries, a range of sample sizes (49 to 15,719 students), as well as a range of grade levels (fifth to 12th). While this study was only able to provide correlative data between interest and achievement, it built a foundation on which other research can be explored. The authors noted that further research was needed to evaluate the effects of other mediators aside from interest, however, running a meta-analysis such as this allowed for an extensive analysis of the correlation between interest and achievement across a large scope of already established research studies (Schiefele et al., 1992).

Harackiewicz (2008) performed a longitudinal study across two academic semesters and investigated the role of not only interest and performance, but also the role of interest in relation to students' achievement goals. The study collected data at five different points in time across the two semesters in order to get a more dynamic analysis of the relationship between these different factors. Interest and performance had a reciprocal relationship in that early interest predicted later exam performance grade and early exam grade predicted later interest. It also found that early interest also predicted the adoption of mastery goals by students which suggests that interest can motivate students to adopt a more task-focused outlook (Harackiewicz et al., 2008).

The results of these two studies suggest the important role of interest in achievement. Even with varied data on the link between interest and achievement, interest at its minimum influences a student's intention to pursue STEM (Grigg et al., 2018; Köller et al., 2001) and at its most direct influences academic achievement (Harackiewicz et al., 2008; Scheifele et al., 1992). In either case, the importance of interest in education is established. If STEM interest is lower in women (Tellhed et. al., 2016), it may go on to impact women's intentions to pursue STEM and their academic achievement in these fields which both contribute to the gender gap.

Therefore, it would be helpful to know the sources of STEM interest. Maltese and Tai (2010) investigated these sources by interviewing STEM graduate students and established scientists. They looked into these students' and scientists' educational histories to see from where and when STEM interest first evolved. In all, 65% answered that their initial interest in STEM began before middle school; while 30% answered that their interest began in middle school and high school. These findings were the same for both men and women. However, initial sources of STEM interest differed between genders. A majority of the men reported an intrinsic source of self-interest, while a majority of the women recounted their initial interest as associated with school. So, the men mainly cited self-initiated activities as the start of their interest, whereas the women mainly discussed external sources as the spark for their initial interest including the likelihood of mentioning teachers as a source (Maltese & Tai, 2010).

Utility Value

In addition to interest, utility value is an important component of subjective task value and motivation (Eccles, 2009). It refers to the value a person places on various tasks. The close connection between interest and utility value and the role in a student's intention to pursue further STEM education was demonstrated in a quantitative study conducted by Brown et al. (2016). Attitude surveys were administered to a total of 206 sixth-grade students, 91 male and 115 female, in a suburban middle school before and after their STEM classes. Utilizing a 5-point Lickert scale, the survey measured the students' self-efficacy, interest in STEM, how useful they perceived it to be (utility value), and the students' intentions to persist in these content areas.

Analyzing the student surveys revealed a significant association between students' intentions to persist in STEM, students' interest in STEM, and students' perceptions of the usefulness of STEM. The perceived usefulness (utility value) was a statistically significant predictive factor for students' desire to continue in STEM courses and in STEM education. In addition, student interest was also found to be a statistically significant predictor of their intention to continue studying STEM. Both of these predictive factors highlight the role of utility value and interest in student choice and participation in future STEM classes (Brown et al., 2016).

The important role of utility value is further supported by a study conducted by Ahmed and Mudrey (2018) who utilized a sample of over 5,000 15-year-old students across 166 schools. The purpose of this study was to investigate different motivational factors such as science utility value and science enjoyment and their influence on students' STEM career aspirations. Results of the study indicated that both enjoyment of science and science utility value were significant predictors of students' STEM career aspirations for both men and women. However, utility value was a stronger predictor for female students than male (Ahmed & Mudrey, 2018). This suggests that female students who were able to perceive science in school as useful were more likely to aspire to careers in STEM demonstrating the crucial role task value plays in women's STEM careers. However, this study collected data from a single point in students' educational careers; it did not explore how these factors evolve over time.

This evolution of STEM interest and utility value was explored by Petersen and Hyde (2017). This longitudinal study was conducted to investigate the trajectory of students’ perceived math ability, utility value, and interest from fifth to ninth grade. The results reported a decrease in both students' math utility as well as their interest throughout the course of these grades. In particular, fifth-grade students who reported that math was useful also reported a steeper decline in the utility value of math and math interest in the following years than those students who did not report as strong of an indication of math usefulness. It also found that all three motivational factors (perceived math ability, math utility value, and interest) correlated with each other. This suggested that an improvement in one area of these motivational factors is likely to contribute to an improvement in the other factors as well (Petersen & Hyde, 2017).

While Petersen and Hyde (2017) did not find gender differences in math utility value and math interest in their particular study, a longitudinal study conducted by Wang et al. (2015) observed the role that gender played in math interest and value. This study tracked students starting as early as seventh grade and followed them through their adulthood into their 30s when students had established chosen careers. Several measurements were considered, including math and reading achievement, math ability confidence, task values, and work preferences. Initial findings reported that men had higher math achievement than women and that more men went on to choose STEM careers. After analyzing the different potential factors contributing to those who chose STEM careers, valuing math had a significant association with math achievement which was then associated with choosing a career in this content area. Inversely, women reported valuing math less. This was then associated with women’s lower math achievement and likely contributed to the lower rate of STEM careers for women (Wang et al., 2015). Similar to the previous study, the value placed on math had a greater contribution to achievement and choosing a STEM career than self-efficacy. This indicates that belief in one's ability may aid in achievement, but does not necessarily indicate interest or value in a particular topic; as this study demonstrates, belief in one’s ability is a significant and essential factor for those who have chosen a career in STEM.

Gender Stereotypes

Self-efficacy, interest, and utility value are concepts that involve a person’s personal identity. Another important aspect that works in conjunction with personal identity is social identity or social roles. A person’s social identity encompasses values that work to tie a person to a social group or serve to define a person both for themselves and those with whom they interact (Eccles, 2009). In addition to discrepancy in self-efficacy and interest, social impact in the form of stereotypes has correlated with girls’ lower participation and success in STEM as STEM has been disproportionately affiliated with boys (Nosek et al., 2009; Selimbegovic et al., 2019). Friends, parents, and teachers may also consciously or unconsciously influence female students’ perception and preference for classes and careers.

Students as young as first and second grade reported to be either consciously or subconsciously aware of social stereotypes surrounding STEM (Cvencek et al., 2011). A 2011 study of 247 elementary school children in first through fifth grade explored students' unconscious bias that math is a male domain in that they associate the concept of math with the male gender. The study used a self-report measure to test this hypothesis as well as an implicit association test that measures the relative strength of association between different concepts. In this case, the test measured students’ association between math and gender. The researchers asked students to first self-identify as male or female. Then they used the implicit test to measure whether students associate boys or girls more strongly with math or reading. They first found that boys had a stronger sense of their gender identity (i.e., being a boy) than girls had of being a girl. They then found that both boys and girls associated math more strongly with boys than with girls. During the implicit association test, boys were more likely to associate their own gender with math and liking to do math than girls (Cvencek et al., 2011). This was evidenced from first grade all the way through fifth grade with varying degrees of significance.

However, the stereotype that math is a male domain continues as students progress through school and this is supported by a more recent study conducted by Selimbegović et al. (2019). This study was conducted on over 800 students ranging in ages from 10 to 16. Utilizing a career inventory, students indicated to what extent each STEM-related career was more suited for either girls or boys. The responses were measured using a 5-point Likert scale. Gender identification was measured using an assessment with six items that established whether the student saw themselves as a typical boy or girl through a variety of questions.

Selimbgovic et al. (2019) revealed that overall these students held stereotypical beliefs about STEM-related professions. Gender was a significant predictor of the students' expectancies for success in STEM in that boys expected to be more successful than girls which was consistent with gender stereotypes about these careers. This study also analyzed students' gender identity similar to the previous study and found that gender identity also significantly predicted a student's expectancy for success. Essentially, the more strongly a student believed they represented their specific gender the more they followed stereotypical expectations of STEM success. Conversely, when students did not have strong stereotypical beliefs, gender did not relate to expectations for STEM success.

While these STEM stereotypes appear to be held by students in both early and middle education, this may change or differ at the post-secondary level, especially for women who chose math-intensive majors. However, Nosek et al. (2002) found this not to be true. Studying undergraduate students, implicit tests were used to measure students' math attitude, math identity, and math-gendered stereotypes. It was important to implement implicit tests at this level rather than self-reporting questionnaires in order to avoid the conscious influence of egalitarian beliefs at this level of education. These tests were task-oriented and asked students to pair different sets of words together. The idea was that it is easier to pair words (math or arts) with attributes (good or bad, strong or weak, male or female) that have been more often associated previously through experience and, therefore, students will be able to pair them together more quickly.

Results of this study found that while both men and women had a negative implicit association towards math and science, women had a stronger negative evaluation of math and science than their male counterparts (Nosek et al., 2002). Women's attitudes toward math were also more strongly negative than men. In contrast, women identified more strongly with arts than with math. The researchers also found that both men and women were able to classify math more easily with being male and arts with being female than the opposite pairing which suggested that both men and women hold an implicit math-gendered stereotype. In addition, the stronger women reported the math and male association; the weaker women appeared to like math. This gender difference in math attitudes endured even in female students who were actively pursuing math-related majors. Among students in math-related majors, women held more negative math attitudes than their male counterparts (Nosek et al., 2002).

Students were not alone in holding these stereotypes, parents and teachers have also been documented to carry these gendered biases as well (Lavy & Sand, 2018; Starr & Simpkins, 2020). Starr and Simpkins conducted a longitudinal study to investigate the prevalence of math and science stereotypes among high school students and their parents. The study included 22,000 students from 944 schools across the United States. Data was first collected from the students beginning in ninth grade, then collected again in 11th grade, and finally, high school transcripts were collected after students graduated. Surveys were administered to students and parents to measure gender stereotypes, math and science identity, courses taken, and career goals.

In this study, there were no significant gender differences in students' standardized math test scores and girls received significantly higher grades in math than their male counterparts (Starr & Simpkins, 2020). Despite this, parents were three times more likely to believe boys are better at math (28%) and science (21%) than girls. In addition to this, math and science gender stereotypes held by parents positively predicted ninth and eleventh graders' math gender stereotypes and ninth-grade science gender stereotypes. Compounding this, parent and student math and science stereotypes then went on to be significantly related to ninth-grade math and science identity. Girls were more likely to have lower math identity when they and their parents had gendered math stereotypes. Science identity followed a similar trend in that girls' science identity was lower when they and their parents stereotyped males as better at science. This went on to significantly predict the overall number of science and math courses taken by the students in high school. Therefore, not only did the STEM gender stereotypes held by parents influence the stereotypes held by their children, they in turn influenced their children's participation in STEM classes as well (Starr & Simpkins, 2020).

In addition to these effects parents' stereotyped beliefs had on children, teachers' biases are also an additional influence in a student's life (Keller, 2001; Lavy & Sand, 2018). The role of teacher's gender stereotype beliefs was initially evaluated for its influence in a study conducted by Keller (2001). This study looked at 6,000 public school students in sixth, seventh, and eighth grade as well as over 300 teachers from those grade-level classes. Researchers examined the presence and influence of gender stereotype beliefs held by both the teachers and the students. Data was collected using self-report questionnaires for student and teacher beliefs, standardized test scores for mathematical achievement of students, and a Likert scale was utilized to determine student confidence.

Initial findings reported that teachers demonstrated their gender stereotyped belief of math by operating from the assumption that boys would achieve better math grades than girls and deemed math more important to boys' future careers. After controlling for achievement, interest, and self-confidence, the study revealed a significant positive effect of the stereotypes held by teachers on the stereotypes held by students. The more a teacher stereotyped math as a male domain, the more strongly the students also stereotyped math themselves (Keller, 2001).

In a more recent study conducted by Lavy and Sand (2018), the influence of teachers' gender bias was assessed for its influence on student achievement and future outcomes. Focusing on 78 teachers and over 800 students, data was collected over multiple years. It began when students were in fifth grade and continued through high school. Gender bias was measured by comparing a national standardized exam given every two years to teacher graded exams. The national standardized exam was multiple choice and graded by a third party, while the teacher graded exam contained open-ended questions that gave teachers more freedom for grading. The test scores were compared in fifth grade, eighth grade, and at the end of high school.

The initial comparison of the two types of tests in the area of math found that boys' scores were significantly positive relative to girls' scores (Lavy & Sand, 2018). This statistically significant difference suggested that teachers in this sample were favoring boys in math through their grading. When estimating the impact of this bias on student achievement, teacher bias was statistically significant and positive for boys' achievement in the form of their math test scores, whereas the effect on girls was negative, although not statistically significant. These effects continued on into later years of school and were found to have impacted student enrollment in advanced-level math courses in high school as well.

Social Support

There are many ways in which these stereotypes and biases are reflected in the actions and decisions carried out by the support systems of students (i.e., family, parents, teachers, peers which affect students' motivation, engagement, achievement, and participation in STEM) (Bhanot & Javanovic, 2005; Leaper et al., 2012; Jacobs et al., 2005). In a longitudinal study conducted by Jacobs et al. (2005), elementary school-aged children across 10 different elementary schools and their parents were questioned about different STEM-related activities, supports, and attitudes. Mothers were significantly more likely to buy math and science items for their sons than for their daughters. This was evidenced at every grade level, first through sixth grade. Also, a mother's math-promotive behaviors such as purchasing items for their children, mothers' involvement in STEM activities themselves, and mothers' involvement in homework with their children significantly related to later scholastic achievement of their children (Jacobs et al., 2005). Purchasing toys is one way to indicate support for STEM and encourage children to participate in STEM. At this young age, toys are one way in which children are exposed to math and science content. This study suggested that parents appear to create a more math-supportive environment for their sons than for their daughters through exposure to STEM-related toys.

However, purchasing toys is not the only way in which parents can create this gender skewed STEM-supportive environment and pass their gender-stereotyped beliefs on to their children. Another way is through assistance with homework (Bhanot & Javanovic, 2005). Bhanot and Javanovic (2005) sampled 38 fifth through eighth-grade students, 60% girls and 40% boys, and their parents. The sample size was small, however, the results of the study were indicative of parental influence. Each family completed a questionnaire with children self-reporting on their perceptions of their abilities in math and English. After the family completed the questionnaire, they received a homework checklist on which students independently reported on five individual math homework sessions and five individual English homework sessions. Parents were instructed to do the same over the course of a two-week period.

Bhanot and Javanovic (2005) found that parents were more likely to help their sons with homework than their daughters across all subject domains. In addition, mothers of girls were reported to have stronger gender stereotypes in math. This is consequential as parents' gender stereotypical beliefs about math were significantly related to the intrusive support they initiated during math homework. Parents who exhibited these stronger math-related gender stereotypes were more likely to engage in intrusive support of their children during math homework, so that when parents did help their daughters with homework, daughters appeared to be more sensitive to these intrusions especially in math. In this study, parents' gender stereotyped beliefs positively correlated with the amount of help parents provided their daughters and, therefore, parental support of their daughter's homework conveyed their gender stereotyped beliefs to their children.

This uneven exposure and support of children by parents is not restricted to homework, but rather is evidenced in informal settings as well (Crowley et al., 2001). A study conducted at a children's museum analyzed numerous interactions between children and their parents at interactive science exhibits. Data collected over a span of two and half years included 298 interactions between parents and their children who ranged in age from one to eight years old. Of the 298 interactions, 185 families included boys and 113 included girls. The reactions were recorded with video cameras and wireless microphones which were set up at 18 different interactive exhibits in the children's museum. The conversations were then coded into quantifiable data.

The study revealed that parents were three times more likely to explain science concepts to boys than to girls even though boys and girls equally initiated engagement with parents (Crowley et al., 2001). Parents would talk about what to do and what to perceive at the interactive exhibits, but failed more often to provide the explanation of the phenomena being explored at the interactive exhibit to girls. This was true across all age groups. The researchers noted that due to the young age of these children, it is possible that parents may be creating and demonstrating gender stereotypes before their children enter school (Crowley et al., 2001).

If parents express their biased support through buying toys, helping with homework, and informal explanations, it may affect their children in other ways as well (Bleeker & Jacobs, 2004; Leaper et al,. 2012; Stake, 2006). Stake (2006) investigated the role of social encouragement on science motivation, confidence, and attitudes. The study included 184 high school students, 136 girls and 96 boys, from a midwestern area 11th and 12th grade classes. Three physical science classes, five chemistry classes, and five advanced biology classes were selected for this study. Data was collected through a variety of methods. For student ability, standardized testing data in the areas of math and science were used. In addition, teachers were asked to rate their students' ability on a scale of one to seven. Encouragement was collected using self-report questions that utilized different scales to measure students' perceptions of encouragement from family members, peers, and teachers.

The results of Stake's (2006) study revealed that of the three different sources of encouragement examined in this study (family members, teachers, and peers), the encouragement from family members was found to be the greatest predictor of students' science attitudes and was strongly related to their science motivation. The results of this study also suggested that encouragement from both family and teachers was important in order for students to see themselves as a future scientist (Stake, 2006). While this study does not specify parents in particular, it includes a more inclusive idea of family and demonstrates the role of family as a whole in the motivation and attitudes of students in science.

The role of family in motivation and attitudes is also supported by a more recent study conducted by Leaper et al. (2012). The study looked at the effect parent support, specifically, had on student motivation in math and science. The sample for this study included 579 girls ranging in age from 13 to 18 years old. It included data from middle and high schools as well as data collected from school-related programs and summer schools. The students were given a self-report questionnaire that measured parental education, academic motivation, academic grades, perceived academic support, gender identity, and gender-egalitarian beliefs. Data from math and science were grouped together and compared against data from English subject areas.

Overall, the girls' math and science motivation was significantly influenced by parental support (Leaper et al. 2012). Data revealed students' motivation in math and science was significantly related to whether students felt they received positive support in math and science from their parents. Also, students who experienced less conformity pressure from their parents were more likely to have positive motivation in science and math. Findings from the study noted that girls whose parents exhibited less pressure on their children to conform to social gender stereotypes were more likely to have positive motivation in these areas.

However, motivation is not the only factor that parents influence. In a longitudinal study, Bleeker and Jacobs (2004) explored the role of mothers' gender biased expectations for their children and the potential impact it had on their children's science career self-efficacy and career choice. Data was collected at intervals over the course of several years, beginning when students were in sixth grade and continued until the participants were 24-25 years old. In seventh grade, mothers of boys reported significantly higher expectations of success in a math-oriented career than mothers of daughters despite teachers reporting girls' math ability to be significantly higher than boys the previous year in sixth grade. This longitudinally related to their child's career self-efficacy which demonstrated that mothers who had a stronger positive prediction of their children's success in a math-related career were more likely to have children who then reported a higher math-science career self-efficacy later on in their adolescence in the 10th grade (Bleeker & Jacobs, 2004).

The strength of Bleeker and Jacob's (2004) study, though, was its longitudinal look at these factors including the findings from students at age 24-25 years old. The results revealed that female students whose mothers reported a lower prediction of their children's success in math and science-related careers during adolescence were 66% more likely to choose careers in a nonscience field than in a physical science or computing field. This was not the case for sons, however, who were more likely to choose a career in physical science or computing regardless of their mother's prediction of their success (Bleeker & Jacobs, 2004). The longitudinal aspect of this study illustrates the effect that parents can have on their children over a prolonged amount of time into their child's adulthood.

In addition to the effects parents have on children, teachers can be another important influence in a student's life (Bottia et al., 2015). Research conducted by Beilock et al. (2010) investigated the influence teachers had on their students in the areas of STEM at a young age. The goal of the study was to explore the influence of teachers' math beliefs on the achievement of their students. It looked specifically at the effect of teachers' math anxiety. The data was collected from five public elementary schools in a midwestern school district. It included 17 female first and second-grade teachers and a total of 117 students (65 girls and 52 boys). The teachers were surveyed on their math knowledge and math anxiety using a 25-item questionnaire that addressed how anxious different situations would make them based on a five-point Likert scale. Students' math ability was measured using several math problem tests and was tested during two separate data collections, one in the first three months of the students' school year and another in the last two months of the year.

The initial data collected by Beilock et al. (2010) at the beginning of the school year indicated that there was no significant relationship between the math anxiety of the teachers and the math achievement of the students. This changed, however, at the data collection at the end of the year. At that point, the higher the teacher's math anxiety, the lower the female students' math achievement was reported to be. This was not the same for both male and female students. This was only noted in girls; boys did not exhibit this lower math achievement. The influence of a teachers' math anxiety was not only evidenced in math achievement, it also appeared to relate to female students' belief in their own ability. The results of the study conducted by Beilock et al.

(2010) showed that the higher the math teacher's anxiety, the more likely female students' belief in their ability fell along more traditional gender stereotypes about math.

In addition to this, girls who confirmed these gendered beliefs of boys being better at math had significantly lower math achievement at the end of the school year than girls who did not confirm this bias. Researchers noted that it is possible teachers with high math anxiety may be worse at teaching math and that this could have reflected in students' achievement. However, "if it is simply the case that highly math-anxious teachers are worse math teachers, one would expect to see a relation between teacher anxiety and the math achievement of both boys and girls" (Beilock et al., 2010, p. 1862). In this study, this was not the case, though, which suggests there is a significant interaction between teachers' math anxiety and their female students' achievement and beliefs in their ability (Beilock et al., 2010).

Teachers' influence can be measured not only in early education, but also throughout multiple grade levels in a students' education (Yang et al., 2021). The goal of this more recent study was to assess teachers' emotional support for its influence on students' math performance, self-efficacy and math engagement. The sample included 1,294 students ranging from third to fifth grade and from seventh to eighth grade. Students completed online questionnaire surveys in which they answered questions based on a four and five-point scale and math performance data was collected from grade final exams.

Data was desegregated by both grade levels (elementary and middle school) as well as by gender (Yang et al., 2021). The results of this study revealed that teachers' emotional support positively affected math performance. This was true at all levels for all genders: elementary girls, elementary boys, middle school girls, and middle school boys. In addition to this direct effect, researchers also explored the influence student's self-efficacy and math behavioral engagement played between the different factors. While teacher support had a direct effect on students' math performance, student self-efficacy and math behavioral engagement played an intermediary role between them as well.

The impact teachers have on students' engagement has also been investigated by Wang and Eccles (2012). However, Wang and Eccles were able to conduct a longitudinal study by collecting three different data sets from over 1,000 students. The first data set was collected when students were in seventh grade, the second data set was collected when students were transitioning from eighth grade to ninth grade, and the final set was collected in 11th grade. The study strove to analyze the role of social support from parents, teachers, and peers in students' engagement in school which was assessed by a self-report survey as well as face-to-face interviews both of which measured school engagement, school compliance, participation in extracurricular activities, school identification, subjective value of learning, and perceived support (from teachers, parents, and peers).

Initial findings by Wang and Eccles (2012) observed an overall decline in the growth trajectory in school compliance, school identification, and subjective valuing of learning from the data collected in seventh grade to 11th grade. However, the finding also reported that increased social support from teachers related to a higher level of engagement in the different measured areas. Teacher support protected against the normative rate of decline observed from seventh to 11th grade. The influence of teacher support on students' emotional and cognitive engagement was even greater than that of students' peers (Wang & Eccles, 2012).

Yet, peers and friends were still an influential force in students' education as well (Wang and Eccles, 2012). This was first noted by Stake (2006) who reported that while family had the strongest predictor of science attitudes and science motivation, peer encouragement was also an important contributing factor and played an independently important role in motivating students. However, in the study conducted by Wang and Eccles (2012), the role of peers was found to have a more nuanced influence on students. Peer support reduced the decline of subjective task value of learning similar to parents and teachers, but peers were a stronger predictor of behavioral outcomes than teachers and parents although this could be in both a positive and negative way. Researchers considered that this may depend on the type of peers with whom students are associated. Once students were separated into two groups based on whether students reported that their peers demonstrated prosocial behaviors or antisocial values, the researchers found a positive association between peer support and school compliance for students with positive peers and, inversely, negative association between peer support and school compliance for students with negative, anti-social valued peers.

This study conducted by Wang and Eccles (2012) is limited as it did not differentiate the findings based on gender. However, this limitation was not found in the study conducted by Leaper et al. (2012). This study specifically looked at the motivational factors for girls ages 13 to 18, in particular, in STEM domains as compared to nonSTEM domains. This was evaluated by surveying students about how supported they felt from various sources. Using math and science to represent STEM, peer support was found to be a significant predictor of motivation in these two domains. The study then compared this to motivation in English as representative of nonSTEM domains. Peer support for English positively predicted girls' motivation in this domain as well. However, the unexpected result was that girls who experienced support in one domain tended to have weaker motivation in the other domain. That is, girls who had stronger peer support in math and science had weaker motivation in the contrasting domain of English and vice versa (Leaper et al., 2012).

The influence of peers was further supported by a more recent study. Raabe et al. (2019) took gender and STEM-specific domains into account along with peer influence to explore the potential impact they had on student preference. The study considered both friend influence as well as peer exposure effects. Using two different self-report surveys, they questioned 5,025 students across 129 schools and 251 classes over the course of three years starting when the students were in eighth grade between 14 and 15 years old. Friendship was measured through survey items in which students could nominate up to five other students they considered friends. Students were also surveyed about which subjects in school were their favorite. Researchers grouped chemistry, mathematics, natural sciences, physics, and technology together as STEM subjects.

In the initial wave of questions during the first year of the survey, this study found gender differences in students' favorite subject (Raabe et al., 2019). In wave one, 21% of boys said their favorite subject was STEM, while 19% of girls reported STEM as their favorite. This was only marginally significant. However, the difference became more pronounced in the second wave the following year of data where 20% of boys still reported their favorite subject was STEM, while only 15% of girls then reported STEM as their favorite subject. This was a significantly stronger decline for girls. Approximately 21% of girls no longer stated STEM as their favorite compared to the loss of only 5% of boys in the same amount of time.

To build on these findings of peer influence on favorite subjects, Raabe et al. (2019) used subject preference to cross-analyze this data with those whom students listed as friends in the administered survey. They found that the more an individual's friends preferred a particular subject, the more likely that person would be to choose that particular subject as their favorite. They desegregated this information by sex and found while girls' influence on general overall subject preference is positive, but it is not statistically significant. However, this changed when looking at girls' specific preference for STEM subjects. The effect of female students' STEM preference on other female peers was large and statistically significant. This was not seen in the same way for boys' STEM preference. In addition, female students who then had a lower preference for STEM had the potential to be further influenced by others who did not prefer STEM subjects as well. Raabe et al. (2019) noted, "other girls' preferences in the classroom are of particular importance when they counter mainstream gender norms in society" (p. 116).

Chapter III: Discussion and Conclusion

STEM occupations are projected to grow faster than any other occupation over the course of the next decade (Zilberman & Ice, 2021), and their role in the economic growth of the United States, as well as the overall globalization of the world, is crucial. Despite this, STEM remains an area in which women are underrepresented. While women make up 50% of the workforce, they make up only 28% of those in STEM careers.

In order to understand the causes of the gender gap in STEM careers, one can start by investigating the factors that have contributed to the gender STEM gap in education. Women are no longer lagging academically behind men in math and science (Hyde et al., 2008; Hyde, 2016). Therefore, factors outside of aptitude need to be considered, such as women's belief in their academic abilities, interest in STEM, the utility value women place on STEM, and the present gender stereotypes and social influences within this content area (Cvencek et al., 2011; Petersen & Hyde, 2017; Raabe et al., 2019; Selimbegovic et al., 2019; Tellhed et al., 2017).

While researchers have provided evidence supporting girls' aptitude for STEM, they have also revealed the disparity in confidence and belief in ability between the genders (Lloyd et al., 2005). Girls performed academically equal to and at times above their male counterparts in science and math; however, the belief in their ability to be successful in STEM did not reflect this level of accomplishment. Girls reported being under confident and having less self-efficacy than boys even when they were receiving better grades in class (Marshman et al., 2018). According to Huang (2013), this was the case at multiple grade levels from elementary school through the postsecondary level of education.

However, the relationship between performance and one's ability in their belief is more nuanced. Britner and Pajares (2009) suggested that self-efficacy had the potential to predict academic success. This was supported by further research demonstrating the impact of self-efficacy on achievement in the form of problem solving and test taking (Aurah, 2013). In fact, a student's belief in their ability was a greater predictor of success than the background knowledge the student had on the subject (Aurah, 2013; Britner & Pajares, 2009). This then has major implications on the gender STEM gap suggesting that even if women are performing academically well as previous studies suggest, their lower self-efficacy in STEM content may go on to impact their success over time.

Researchers also found that girls sourced their confidence and self-efficacy from different sources than boys. Social comparison and social persuasion influenced girls’ belief in their ability significantly more than their male student counterparts. Using computer surveys to measure what influenced students' confidence, social persuasion accounted for 21% of girls’ responses and only 15% for boys, while social comparison accounted for 5% of girls’ responses and 3% of boy responses (Butz & Usher, 2015). This carries implications for those who are working to address the gender disparity in STEM confidence and ability belief in that different sources of self-efficacy such as social persuasion and social comparison need to be addressed specifically in order to successfully mitigate their effects on girls’ confidence.

Interconnected with this confidence and ability belief is task value. According to the expectancy-value model of achievement, task value plays an important motivational factor in education (Eccles, 2009). This includes both interest in the topic and the value a person places on that task. When discussing STEM careers, researchers have found that interest and enjoyment are some of the topic factors that people cite when choosing a career in these domains (Maltese & Cooper, 2017; Tellhed et al., 2016). This is particularly important as girls beginning in fifth grade reported a much lower level of interest in STEM than boys and it decreased throughout middle school and high school (Frenzel et al., 2010; Sadler et al., 2012). This had a direct correlation with students' intention to pursue a STEM major in postsecondary education as well as a career (Grigg et al., 2018; Harackiewicz et al., 2008; Köller et al., 2001). Overall, this has long-term implications for the gender gap in STEM as interest and task value had extended influences on students' future education and career choices later on in their life.

Another important component of student motivation along with interest is the value students place on certain tasks or domains which is called utility value (Eccles, 2009). Utility value has also been found to have predicted students' desire to continue on in STEM education classes and has predicted their career aspirations (Brown et al., 2016). The influence of utility value was especially true for female students which when coupled with data that revealed a decrease in math utility beginning in fifth grade creates a further disparity in the gender gap (Ahmed & Mudrey, 2018). This is also supported in another longitudinal study by Wang et al. (2015) that reported women valued math lower than men and inevitably were less likely to pursue a STEM career than men.

Persisting gender stereotypes have also influenced female students as STEM has been more closely associated with boys than with girls. Students as young as first and second grade reported being either consciously or unconsciously aware of these gender stereotypes (Cvencek et al., 2011). Both young girls and boys were more likely to associate math in particular with boys and this persisted in older students as well from middle school all the way through undergraduate students. Even female students who chose to major in a STEM major were found to have a negative attitude toward math (Nosek et al., 2002; Selimbegovic et al., 2019).

These stereotypes are also held by teachers and parents who serve as social support for their students and children, and there are multiple ways in which they express these stereotypes

(Bhanot & Javonovic, 2005; Crowley et al., 2001; Jacobs et al., 2005). Teachers have been documented to hold gendered biased views which has biased their grading and influence their students' achievement and participation in STEM in later years of school (Lavy & Sand, 2018). This has been seen even at a young age with elementary teachers' math anxiety which has been demonstrated to influence female students' academic performance in math (Beilock et al., 2010).

Stereotypes held by parents have also been reported to influence their children in different ways. For example, parents are more likely to buy STEM-related toys for their sons than their daughters and they are more likely to explain scientific content to their sons in informal settings such as a museum (Crowley et al., 2001; Jacobs et al., 2005). Both of these are initial ways of engaging young children in the STEM domain. Parents are also more likely to be driven by gender stereotypes when helping their children with homework. This affects the way in which girls view the intrusive help given by their parents and are more likely to be sensitive to this than boys (Bhanot & Javanovic, 2005). The ramifications of this can be great and long lasting. Additionally, the stereotyped beliefs held by parents related to their child's career self-efficacy in later adolescents. Specifically, female students whose mother had these stereotyped beliefs were less likely to pursue a STEM career later in adulthood (Bleeker & Jacobs, 2004).

Peers are the third component studied as a social support and influencer, and friends and peers appeared to have a more nuanced influence on students (Stake, 2006; Raabe et al., 2019; Wang & Eccles, 2012). Stake (2006) found that peer encouragement was an important component of students' motivation in both math and science. However, in a study conducted by Wang and Eccles (2012), the influence of peers was both positive and negative depending on the type of friends with which the student interacted. This was similar to Raabe et al. (2019) who reported girls' preference for STEM, in particular, their friends' influence. If a student's friends had a more positive preference for STEM, then that student was more likely to prefer STEM content areas as well.

Overall, girls demonstrated lower belief in their own ability in STEM domains than their male counterparts (Huang, 2013; Lloyd et al., 2005; Marshman et al. 2018). They also reported lower levels of interest and utility value in STEM (Frenzel et al., 2010; Tellhed et al., 2016; Wang et al., 2015). These factors as well as the stereotyped beliefs held by parents and teachers all played crucial roles in the participation and success of girls and women in education (Bleeker & Jacobs, 2004; Cvencek et al., 2011; Nosek et al., 2002). Each component worked both uniquely and in coordination with other factors to contribute to the gender gap observed in STEM education.

Professional Application

This body of research aims to clarify some of the contributing factors to the STEM gender disparity. It serves as information to both parents and teachers about the different factors affecting their children and students. As these factors influence girls and are contributing to the gender gap in STEM education and women's careers, this research can guide parent behavior and teacher choices in order to better serve female children and students. Being aware of girls' lower self-efficacy, the role of task value, and the impact of gender stereotypes can inform choices adults make so they can better influence the young women around them.

It can also be used to inform and create intervention strategies to aid in closing the gender gap in STEM. Utilizing the research on these contributing factors can aid in the evaluation and creation of interventions in order to target specific areas in women's educational and professional careers. For example, by understanding that women’s self-efficacy stems more from self-esteem and lack of confidence (Zander et al., 2020), teachers would be able to address the lack of self esteem girls have after tests by immediately releasing scores so that female students receive more immediate feedback. This would mitigate the low levels of self-esteem Zander et al. (2020) observed in female students immediately after tests. This would allow better support and encourage girls’ confidence in STEM classes.

Interventions have been reported to successfully address some of the factors that contribute to gender disparity. For example, Schilling and Pinnel (2019) examined the effectiveness of four specific engineering camps. They found that these engineering camps were able to increase participants' self-efficacy in engineering, math and science by the end of the six day camp. In particular, single-sexed camps had a positive effect on the girls who participated and increased their level of confidence in these domains. This is just one example, however.

Limitations of the Research

One limitation of this research is the narrow scope of the racial and ethnic backgrounds of the participants in many of these studies. While some studies did include the racial breakdown of the participants in their methodology, 21 studies failed to identify the racial demographic of their sampling altogether. However, of the 14 that did identify the racial demographics of their study, 12 primarily focused on populations of which the majority (if not the entire group) was white. One study addressed its demographics in which 90% of the sample was white as an appropriate representation of the population of the state in which the study was conducted (Peterson & Hyde, 2017); however, other studies failed to validate their lack of a diverse research sample. Some studies explored the implications of the exclusion of minorities. Britner and Pajares (2006) noted that this limited the understanding of how the factors' investigated in their study influenced women in minorities especially since minorities are also underrepresented in STEM as well. Some studies have worked to explore the intersectionality of gender and race in the STEM gap with positive and more inclusive results; however, this included only a few studies (Ahmed & Mudrey, 2019; Leaper et al, 2012; Wang & Eccles; 2012). In order to support all girls and women, there needs to be a more intentional investigation of the intersection of race and gender in STEM education.

An additional limitation was the lack of a clear definition of gender. It appeared that studies relied on a binary classification of gender as male and female; however, this was not explicitly addressed. In addition, while Selimbegović et al. (2019) addressed their use of a self-report survey to identify gender and Tellhed et al. (2017) stated they recorded participants legally assigned gender, most studies failed to include how gender was determined or identified in their samples. While transgender and gender queer students remain a small portion of the population, they were also not addressed in these studies. It is important to note this strict gender dichotomy and the failure to identify how gender was determined for use in studies may leave out these students in the body of research.

Finally, a large portion of the foundational research on the different factors that have contributed to the STEM gender gap was conducted over 20 years ago. This dated information may lead to inaccurate data in the context of today's climate, especially for those that investigated the stereotypes held by parents and teachers. While this was partially addressed with the inclusion of more recent studies such as Star and Simpkins's (2020) study, due to evolving gender roles and representation in the 21st century, additional research is needed to update changes in math and science stereotypes held by teachers, parents, and students alike.

Implications for Future Research

In order to fill the gap on the intersectionality of race and gender in STEM, more research is needed to explore how race and gender interact in a STEM setting and how the factors that contribute to the gender gap impact students of different races and ethnicities. Students of diverse racial-ethnic backgrounds may experience ability belief, interest, utility value, stereotypes, and social pressures in unique ways. For example, Latina students reported feeling more gender conformity pressure from their parents than white European-American girls (Leaper et al., 2011). Therefore, in order to more accurately mediate these factors in various student populations and create effective interventions, we need to be aware of the differential impact these factors have in various populations of female students. Future research should move from comparing male and female students to comparing these various contributing factors among a diverse population of female students.

In addition to exploration of the intersectionality of race and gender, further research is needed into the causation of the different factors that contribute to the gender gap. The primary research of this literature review relied on observational and correlational studies. While this research is important for understanding and creating hypotheses, it does not give a definitive cause of findings such as the lower level of self-efficacy in women. Educational intervention research is able to manipulate different variables to establish the causations of these factors. Using interventions provides insight into the casual relationship between the factors discussed in this literature review and educational and motivational outcomes. While there is a research base on interventions, most have focused on later adolescents and college level students

(Lazowski & Hulleman, 2016). There is limited research on educational interventions at the elementary and middle school level. However, lower self-efficacy, lower interest, and gendered stereotypes were present during these early grades which suggests a need for effective interventions at this level.

Conclusion

While Hyde et al. (2016) reported that girls no longer fall behind their male counterparts by achieving academically similar on state standardized testing, there remains a gender gap in participation and success in the areas of STEM (National Science Foundation, 2018). This literature review aimed to address the different factors that have contributed to the gender gap in STEM education such as girls' belief in their ability, their interest in STEM, utility value, social supports, and the influence of gender stereotypes.

Initially, by investigating women's self-efficacy in a meta-analysis, Huang (2013) found that girls had a significantly lower level of self-efficacy in STEM content areas compared to boys. This is imperative as self-efficacy was a strong predictor of student performance and achievement (Aurah, 2013; Zander et al., 2020). However, self-efficacy was not alone. Social support from teachers, parents, and peers also impacted student performance (Beilock, 2010; Bleeker & Jacobs, 2004; Yang et al., 2021). These support systems also significantly influenced student motivation as well (Leaper et al., 2012; Raabe et al., 2019; Stake, 2006).

Interest was another factor explored in this review, playing a role in student motivation and achievement by positively predicting students' intention to pursue STEM as well as later student academic performance (Grigg et al., 2018; Harackiewicz et al, 2008). Utility value worked closely with interest as they are both components of subjective task value (Eccles, 2009). Results from a study conducted by Ahmed and Mudrey (2018) found that utility value strongly influenced girls' STEM career aspirations. The impact of interest and utility value is concerning as girls reported lower levels of both STEM interest and utility value (Frenzel et al., 2010; Petersen & Hyde, 2017). These can compound when considering the additional impacts of gender stereotypes in STEM content areas. The results of Starr and Simpkins (2020) found that parents were three times more likely to believe boys are better at math than girls which then impacted the stereotypes students held as well as their math and science identity. However, parents and students are not the only ones who hold these stereotypes. Teachers also reported these biases (Keller, 2001; Lavy & Sand, 2018) These stereotypes held by parents, teachers, and students have influenced girls in STEM significantly by affecting their expectation for success and influencing their belief in themselves (Lavy & Sand, 2018; Selimbgovic et al., 2019).

This review of the research enables a better understanding of the different components that have contributed to the gender gap in STEM education. Rather than relying on historic notions of women's lack of aptitude, we can discern far more that has contributed to this gender disparity. Fortunately, the research builds a foundation for bringing awareness to these different factors in order to provide information to parents, teachers, and students. As well as to provide insights in order to create interventions that can work to mediate these factors encouraging and aiding more young female students to pursue STEM education and perhaps one day a STEM career.

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