STEM Educators’ Perceptions of Gender Bias and the Contributing Factors That Persist for Women in STEM Education

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STEM EDUCATORS’ PERCEPTIONS OF GENDER BIAS AND THE CONTRIBUTING FACTORS THAT PERSIST FOR WOMEN IN STEM EDUCATION

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DEDICATION

This is dedicated to my parents, Melissa, Nana, and Lauren. My family has provided me with the roots of knowledge and perseverance. Lauren who has continued to encourage my pursuit of knowledge. My twin sister Melissa has provided confidence and reassurance. Always.
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ABSTRACT

Social influence from society holds the key to social norms that influence students and their future aspirations. Gender bias is considered one of the influencing factors that affects the decisions of female high school students on participating in STEM education. This descriptive study describes the key factors that STEM educators perceived as influential for female high school students' participation in STEM education. The research questions of the study included: (1) What are high school STEM educators’ perceptions regarding gender bias in the STEM School of Study cluster at Skyler High School and (2) What factors do high school STEM educators perceive as contributing to low participation among female high school students within the STEM School of Study cluster at Skyler High School. The study consisted of twenty participants STEM educators at Skyler High school. The five data collection sources included: Perceptions of STEM Participant Survey, DASS Instrument (DASS), Sex Typing of Occupation Survey and Semi-structured interviews. Quantitative data analysis was conducted by performing descriptive statistics including mean and standard deviation. Frequency counts were conducted to analysis the data from the Sex Occupation Survey. Qualitative data was analyzed through inductive analysis, peer debriefing and member checking. The study found an educational push for female students to enroll in humanitarian courses. The study revealed that gender bias, biological influences, social norms, stereotypes of STEM students and underrepresentation of female students can influence female high school student’s enrollment in STEM education. The participants perceived certain careers as
more feminine or masculine, such as a registered nurse as feminine and waste management as masculine. The influential factors perceived by the STEM educators align with Bandura’s Social Cognitive Theory (1997) of behavioral, environmental and individual factors. The significance and implications of this study was to explore the influential factors that educators perceive to create a barrier for the underrepresentation of females in STEM fields and education. Based on the findings of this study, recommendations for increasing female high school female students in STEM education including early interventions, professional development, and community involvement will be discussed in the recommendation section of the chapter.
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CHAPTER 1

INTRODUCTION

Female representation in Science, Technology, Engineering and Mathematics (STEM) continues to decline even with the increase in educational programs and technological advancements in society demanding STEM professionals. In 2019 statistics from the National Science Foundation National Center for Science and Engineering statistics found that 38.9% of women graduated with a STEM undergraduate degree. This phenomenon has called for researchers to explore the influential factors that contribute to the decline of women in STEM education and careers that has created a gender gap in STEM education (Card & Payne, 2021). Despite the efforts to provide STEM opportunities in K-12th grade education, a decrease in female representation in higher levels of STEM education persists. The gender gap has called researchers to explore the key factors of behavioral, individual, and environmental influences that contribute to the decrease in females in STEM education and careers. The main factors explored by researchers include social roles, stereotypes, social influence, self-efficacy, self-determination, and social economic factors (Hand and Green, 2017; Kong, Carroll, Lundberg, Omura & Lepe, 2020; Liu et al., 2014; Riegle-Crumb and Moore, 2014).

Past research confers the need for an organizational change in STEM education by expanding the research to identify factors that influence the perceptions of female STEM students. The gender bias that is unconsciously and consciously placed within STEM
education in terms of gender creates a gap that continues throughout the educational life of students (Smeding, 2012). “Most scholars agree that there is a gender disparity across science, technology, engineering, and mathematics (STEM) fields” (Moss-Racusin, Sanzari, Caluori & Rabasco, 2018, p. 651). In this descriptive study, a mixed methods approach was used to explore STEM educators' perceptions toward gender bias in a high school STEM education system. Quantitative and qualitative data was collected to describe STEM teachers’ perceptions of gender bias in STEM education and their perceptions on influencing factors, if any, that affect female involvement in STEM classes.

**National Context**

The U.S. Bureau of Labor Statistics (2021) projected that between 2020 and 2030 STEM occupations are projected to increase by 10.5% compared to non-STEM occupations increasing 7.7%. The median average wage for the STEM occupations is over half of a non-STEM occupation. STEM occupations seen in the fields of computers, mathematics, architecture, engineering, life science, physical science, and postsecondary teaching occupations. Women are still underrepresented in STEM occupations even with the increase in opportunities for individuals (Bishop, 2015). The U.S Bureau of Labor Statistics reported in 2019 that women are substantially underrepresented in STEM related occupations. “For example, 18.7 percent of software developers, 27.6 percent of chief executives, and 36.4 percent of lawyers were women, whereas 88.9 percent of registered nurses, 80.5 percent of elementary and middle school teachers, and 61.7 percent of accountants and auditors were women” (BLS Reports, 2021, para. 11).
The United States government presented the National Strategy of Gender Equity and Equality (2021) that outlines key strategies to combat the gender gaps in the United States and to promote Equality.

That Executive Order also mandated the development of this first-ever national strategy to guide our work on gender equity and equality as a government and as a nation. This strategy outlines an ambitious agenda for this Administration and those to come—a roadmap to help our nation close pernicious gender gaps and propel us toward a world with equal opportunity for all people (Biden, 2021. pp. 3-4).

In the past decade, the College Board (2020) has included Advanced Placement Computer Science Principles (AP CSP) and encouraged diversity among students taking STEM courses in high school and college. “Students who take AP CSP in high school are more than 3 times as likely to major in computer science in college, compared to similar students who did not take AP CSP” (para. 11).

Despite the increase in nationally accredited programs, government support and STEM courses offered to students in secondary education the decrease in female participation in STEM education and fields continues to decrease (Kaleva, Pursiainen, Hakola, Rusanen, & Muukkonen, 2019). Overall women received 57.7% undergraduate degrees compared to 42.3% of men. In STEM undergraduate degrees women only represented 38.9% versus 61.1% male (Charlesworth & Banaji, 2019). Society places social norms on career fields that affect the overall representation of diversity within the fields, including STEM education and careers.
Local Context

South Carolina Department of Education (2020) states that with the implementation of current policies in South Carolina (SC) schools, female students’ representation in Advanced Placement (AP) STEM classes has increased. The report only includes AP STEM statistics and fails to report the overall STEM education involvement by female students across all STEM courses in South Carolina schools or the percentage of female students that continued their educational careers in STEM fields. On a state level SC has implemented South Carolina Coalition for Mathematics and Science, K-8 South Carolina Computer Science and Digital Literacy Standards, South Carolina Computer Science Standards for High School, and International Society for Technology in Education (ISTE) standards to increase STEM learning opportunities for students in SC. “Students participating in STEM exams have more than doubled over the past ten years from 7,436 exams in 2007 to 14,391 in 2017” (NCES, 2015). In 2019 more female students took the SAT than males and only 18% of the test takers indicated aspirations to pursue a college major in STEM (College Board, 2019).

Academically, in 2017, Skyler High School received a good rating when comparing school, district, and state assessment scores. The rating is determined if the overall score ensures that all students meet the SC Graduate profile to be prepared for high school graduation. In 2020, only 25.4% of students were enrolled in AP programs at Skyler High school and Skyler High School Students represented 3.7% enrollment at the Applied Technology Center. The Skyler High School student population in 2021 was approximately 2586 with 183 faculty/staff. Female students represent 51% of the population and 49% male. The school is diverse with seven ethnicities represented in the
student population. 46% Caucasian, 34% African American, 13% Hispanic, 4% Multiracial, 4% Asian, 0.3% Native American, and 0.1% Pacific Islander. This data could be affected by the Coronavirus (COVID) outbreak due to some students participating in Virtual South Carolina online courses.

My experience in STEM education is teaching middle and high school STEM courses, including an advanced Project Lead the Way Course and Fundamentals of Computing. The advanced Project Lead the Way Course was created by Massachusetts Institute of Technology and included user interface development and app creation using JavaScript block coding. The Fundamentals of Computing course is one of the courses that students in SC can take to earn their one required unit for computer science to be eligible for a high school diploma. The programs that I have integrated into my classes over the years have introduced diversity, especially regarding gender diversity representation. With the increase for hands-on experiences that are diverse, including LEGO courses, financial courses, and robotic courses, this may have created a gender gap because of the stereotypes that are put on those courses from society.

Skyler High school in Duo, SC, has a diverse population of students and STEM courses. The gender statistics for Skyler High School is 51% male and 49% female (NCES, 2015). There are four individual STEM courses, two Project Lead the Way courses, and one computer programming course. Non-advanced placement STEM courses are also offered including college preparation STEM courses that are required to be eligible for a high school diploma. Students that are enrolled in the advanced placement courses in STEM earn a certificate and participate in off-campus internships. Students that qualify for the STEM certificate and off-campus internships must be
enrolled in honor-level or AP courses. The students that are recommended by their STEM teachers must then complete an application and be accepted into the STEM program to be eligible to participate. Skyler High School students can attend the Applied Technology Center that provides students with the opportunity to earn certifications in automotive, nursing aide, cosmetology, culinary arts, firefighting, and hazardous materials operations.

Statement of the Problem

Female representation in STEM continues to decrease on a local and national level despite the attempt at equality. This female underrepresentation has led me to describe what factors are influencing female high school students’ lack of interest in a STEM education as determined by the perceptions of STEM high school educators.

Purpose Statement

The purpose of this descriptive research study was to describe Skyler High School STEM education teachers’ perceptions of gender bias and factors contributing to low female enrollment in STEM courses.

Research Questions

1. What are high school STEM educators’ perceptions regarding gender bias in the STEM School of Study cluster at Skyler High School?

2. What factors do high school STEM educators perceive as contributing to low participation among female high school students within the STEM School of Study cluster at Skyler High School?

Statement of Subjectivities and Positionality

The decision to pursue a graduate degree in educational technology stems from my underlying issue with the stereotype that society has placed on STEM teachers. From my perspective, STEM education should enhance students' learning experiences in all
academia to provide each student with an optimal learning experience. STEM education, however, is misunderstood within the educational system and is taught in addition to the core classes required by the policies of the educational system (Kelley & Knowles, 2016). An ideal educational technology professional is immersed in the current technology-based instructional tools and training that provides the professional with the available resources to utilize in the classroom. My personal experience as an educational technology professional includes experience with online learning by receiving my undergraduate and graduate-level degrees online, and by doing so, understanding the professional framework of technology education. My experience in organizational management through my undergraduate degree helps to decompose concepts in STEM education down into smaller ideologies and understandings.

My research paradigm for this research study is Critical Theory. My research is considered Critical Theory because ontology is social, cultural and gender values that evolve over time and affect the current state of education. My action research places a central importance of female high school student enrollment in STEM education that effects representation of women in STEM education and career fields. Transactional describes the epistemology of my student because the findings are meaningful from the voice of the participants through semi-structured interviews.

Individual experiences that present challenges for me to be an ideal educational technology professional include confidence in my intelligence and speaking up for ideas that I am enthusiastic about implementing in my classroom. The fear of failure prevents me from putting all my effort into my studies. I am committed to being a lifelong learner and advocate for my students. The current professional challenges that are present are the
lack of resources, funding, and individual pride in not needing assistance. Also, teamwork is essential when advocating for all students in education. I am interested in the gender bias of high school female students and STEM education. I am interested in female participation in STEM courses and factors that influence students' decision to enroll in STEM courses. This research included collecting STEM educators’ perceptions on gender bias in STEM education and the underlying factors that they perceive to influence female students in participating in STEM courses.

As a female in computer education, I am not the stereotypical computer science teacher that society has determined the social norm. As a student and educator in STEM courses I have experienced real-world examples regarding females in STEM education and careers. My pedagogy involves being a mentor for my students and assisting each of my students in meeting their individual learning goals. The foundation that I incorporate in the classroom is using real-world culturally responsive scenarios that the students can relate to. These have students utilizing problem-solving skills by creating solutions to real-world community problems. My passion is to expand my students’ worldviews and understanding of the world by providing relatable experiences through STEM education and technology. The research limitations included under-qualified educators in STEM education, decreased professional development and implementation of the new STEM curriculum. This study will impact current research because the fundamental process of the study was to describe key factors STEM educators perceive to influence female students’ participation in STEM education that coincide with the decrease of their future aspirations in STEM education and careers.

**Definition of Terms**
**STEM.** STEM is the acronym for Science, Technology, Engineering and Mathematics.

The concept of STEM is to integrate practices for student engaged learning utilizing problem-solving activities where students create evidence-based solutions.

**Gender Gap.** The under representation of females in STEM education and STEM fields influenced by behavioral, individual, and environmental factors.

**Gender Bias.** Gender bias is the conscious and unconscious bias that is created in the classroom including curriculum/material/classroom interactions (student and teacher) that favor one gender over the other and that discourages gender equality in the academic environment.

**STEM Educators.** Teachers that are certified in specific STEM education courses and teach high school science, technology, engineering, and mathematics courses.
CHAPTER 2
LITERATURE REVIEW

The purpose of this action research study was to describe STEM educators’ perceptions pertaining to gender bias in STEM education, including factors that STEM educators perceived to influence low participation of female high school students in STEM education. The literature review was conducted based on the two research questions of the study, what are high school STEM educators’ perceptions regarding gender bias in the STEM School of Study Cluster at Skyler High School and what factors do high school STEM educators perceive as contributing to low participation among female high school students within the STEM School of Study cluster at Skyler High School?

Methodology of Literature Review

The delimitation of the literature review was specific to high school STEM educators’ perceptions of female high school students’ participation in STEM education, including the factors that influence female high school students to enroll in STEM education. The gap in the literature includes the absence of research on the specific topic of gender bias, specifically in STEM education referring to gender. In past literature, researchers concentrated on whether male or female students scored higher or performed academically better in STEM courses by providing statistical data to correlate scores with achievement in STEM careers. The research of gender gap in STEM careers is extensive but the lack of research pertaining to the educational setting and factors that influence
choices of STEM involvement are not examined thoroughly. “Though much research has been conducted on gender role bias in the workplace, there is a lack of this type of research in an educational setting (Hand et al., 2017, p. 933). Bandura’s Social Cognitive Theory (1997) underlies factors that contribute to gender bias, such as behavioral, individual, and environmental influences, and how those affect students’ academic decisions are explained. The interaction between a person and their environmental factors is called reciprocal determinism, which is also a central premise of Bandura’s (1986) Social Cognitive Theory.

At the beginning of the research, a systematic search was conducted using keywords and parameters derived from the study’s research questions. The main variables that were researched were educators’ perceptions on gender bias in STEM education and perceptions of influences or factors that affect female students’ decisions about STEM education. The systematic review was initiated by searching multiple databases on the online University of South Carolina Library website. The databases used in the search included Education Source, ERIC, EBSCO, ProQuest, ACM Digital Library, University of South Carolina Dissertations, and Theses Global. Boolean operators were used to search the keywords: gender gap, gender bias, STEM, female high school students, STEM, educators’ perceptions, best practices, influences, stereotypes, leaky pipeline, Social Cognitive Theory, and social roles. The parameters used included search results from the past 12 years, full text, scholarly, and peer reviewed.

The first search was conducted with keywords educators AND perceptions AND gender bias AND STEM. The filters used in the search were sorted by relevance, peer reviewed journals, from 2000-2021, articles, book chapters, books, datasets, dissertations,
and journals. The search resulted in 4,805 results. The second search was conducted using the database Eric (ProQuest) online University Libraries website. The keywords used for the search were gender gap AND STEM AND female high school. The filters for the study were peer-reviewed publications in the last 3 years. The search results resulted in 43 scholarly journals and 3 books. The third database used was EBSCOhost and Boolean/phase was gender bias AND stereotypes OR social roles. The results were filtered to full text, scholarly peer reviewed journals from 2005 to 2021 all source types. The results yielded 2,087 results. The keywords for the literature review parameters were gathered from the main research question terms discussed in the purpose of the research study.

When a systematic search was conducted on past literature on the gender gap in STEM education a plethora of studies, journals and publications were returned. The results were filtered to include the most relevant peer reviewed articles from the last 7 years. Research in the past years has concentrated on the factors that contribute to the gender gap and recommendations to decrease the gap for underrepresented students, including females in STEM education. This literature review section will consist of (1) the history of STEM education (2) current STEM education, (3) gender bias, (4) perceptions on gender bias in STEM education, and (5) theoretical framework.

The History of STEM Education

The first implementation of the acronym STEM in K-12th grade education was in 2001 by Judith Ramaley, an employee of the U.S. National Science Foundation (Breiner et al., 2012). Researchers confer that STEM education has been highlighted in multiple research studies over twenty-two years, even with the brief time of the creation of the
acronym for K-12th education (Nash, 2017; Robertson 2019; Sansone, 2019). The acronym and definition for STEM education was updated in 2001 by the U.S. Department of Education to recognize the need for future Science, Technology, Engineering, and Mathematics in the workforce to prompt an increase in STEM courses and early exposure of STEM courses in K-12th education. The increasing need for STEM occupations would suggest an equal opportunity for students to pursue STEM education. The expansion of STEM education in K-12th grade and the push from educators to increase a diversified curriculum was intended to create equal opportunities for students (Holmlund et al., 2018). The result in return caused a significant gender gap that past research studies have explored, including statistical data provided by the U.S. Bureau of Labor Statistics (2017).

**Current STEM Education**

Allen and Peterman (2019) define informal STEM education as “lifelong learning in science, technology, engineering, and math (STEM) that takes place across a multitude of designed settings and experiences outside of the formal classroom” (p. 18). Researchers easily define English and Math but with the complexity of adding STEM into the requirements for subject areas, there lacks consistency as the STEM definition continues to evolve to meet the needs of the current educational needs and societal influences (Margot & Kettler, 2019). Xie et al. (2015) describes the evolution of the STEM definition as “schools differ widely in resources for STEM education, such as teacher quality and science laboratories, primarily reflecting cross-school inequalities in family and neighborhood SES” (p. 8). The concise reasoning for the importance of
STEM education is to prepare students to make decisions by problem solving but for each school, community, or problem being solved there are too many factors to give a one shoe fits all definition (Gonzalez & Kuenzi, 2012). Therefore, STEM education continues to be paired with the ever-changing need for STEM disciplines in the dynamic workforce and each individual experience to utilize STEM education.

**Gender Bias**

The operational variable perception is defined by past research as explicit and implicit attitudes or stereotypes that educator unconsciously or consciously are aware of in STEM education (Charlesworth & Banaji, 2019; Londot, 2018; Pantic et al., 2018; Robertson et al., 2019; Wang & Degol, 2017). Medina-Jerez et al. (2010) conducted research with Colombian and Bolivian educators comparing their perceptions of gender bias in comparison to standardized scales and determined the measurement of bias referring to gender as an internally issue. Gender bias in this research study will align with the definition of Wang and Degol (2017): the conscious or unconscious bias created in the classroom, including curriculum/material/classroom interactions (student or teacher), that favor one gender over the other and that discourages gender equality in the academic environment.

The research of Kong et al. (2020) and Sax et al. (2017) found that gender bias is rooted in social norms and discriminatory practices causing a social cognitive approach to determining the key factors that contribute to low participation in STEM for females. Contradicting studies indicate a decrease in the gender gap in STEM education by gender. Grossman and Parch (2014) and Moss-Racusin et al. (2018) determined in their studies that the statistical data in the contradicting studies that show a decrease in gender bias are
comparing test results by gender and not the primary variable of gender bias by gender. Determining the decline in the gender gap in STEM only by comparing test results excludes the underlying factors that result in underrepresentation of females in STEM education and professions. “Discriminatory practices are rooted in larger cultural and social norms, and the definition of gender discrimination is continually evolving” (Kong et al., 2020, p. 55). Realizing that key factors influence female students on participating in STEM courses has caused the need for research on the contributing factors instead of research on test scores in STEM by gender to create equality in STEM education. Sax et al. (2018) defines gender inequality as comparing female and male students by factors such as test grades, interaction, future aspiration, and attitudes.

**Perceptions on Gender Bias in STEM Education**

In 2018, Londot conducted a qualitative descriptive case study to explore the perceptions of high school STEM teachers pertaining to the phenomenon of the decrease in female high school students not selecting a STEM pathway degree program. The themes that emerged from the Londot study included (a) hidden bias, (b) family, (c) socioeconomics, (d) gender, and (e) self-concept. Londot described the phenomena by connecting the themes to Social Cognitive Theory and utilized a survey that included open-ended questions to gather data for qualitative analysis. Additionally, focus groups were created to collect qualitative data that was analyzed by coding the transcripts of the focus group discussions. An analysis of themes was conducted to connect the overarching themes from the two data collection sources into categories and themes. The 21 participants of the Londot study were chosen using purposeful sampling and included solely STEM educators in the research study. The limitations of the study included the
limited perspective from just including STEM educators as participants of the study, along with research bias due to the researcher also being a STEM educator. Londot found three themes: “STEM teacher bias, barriers, and future context of female STEM students” (pp. 134-135). The subcategories of the themes were tied to Social Cognitive Theory including socio economic factors, gender bias, biological, culture, self-concept, and support from home. The subcategories were categorized within the three main factors of Social Cognitive Theory: behavioral, individual, and environmental.

Researchers have pointed out that STEM education and careers fall under a society norm of being nerdy and masculine. Pantic et al. (2018) conducted two case studies to collect drawings of a scientist to examine the perceptions of youth on the stereotypical characteristics associated with scientists. The Draw-a-Scientist Test (Mercier et al., 2006) was used to collect data for the study. The students were asked to draw what a scientist looks like as well as answer two questions, how you would describe a scientist and what a scientist does in their job. The perceptions of middle school student participants were the main variable of the study to examine interest, beliefs, and self-efficacy pertaining to computer science. A deductive analysis and open coding approach was used to create a list of stereotypes to measure the responses offered in the drawings. Mercier et al. (2006) found only the female campers drew female scientists. When using the same drawing instrument, Pantic et al. (2018) found only 11.5% of participants (including both genders of participants) drew female scientists. The Pantic et al. study concluded that stereotypes do exist, and the stereotypical scientist was a male that wears glasses and is in a white lab coat. The limitations of one of the Pantic et al. studies included a small sample of 72 students with the mean age of 11.6 that attended a science
summer camp. Also, the study concentrated on physical appearances rather than the factors that can influence the perceptions of the middle school participants.

Hand et al. (2017) conducted a mixed method study to ask both students and teachers their perceptions of subtle forms of gender bias in traditional gender roles, pertaining to stereotypes in the educational setting. The study distributed two surveys, one for teachers and one for students, to describe gender role bias in STEM classes. The surveys prompted participants to determine if a role was perceived to be more masculine or feminine using the Dimensions of Gender Role Stereotypes instrument (Diekman et al., 2010). The instrument rated the participants' responses using a Likert-rating scale. “The responses on appropriate items were then averaged to create a score for STEM subjects ($a = .67$) and a score for humanities subjects” ($a = .53$) (Hand et al., 2017, p. 934). Using pairwise comparisons, the study determined teachers associated STEM professionals more strongly with masculine cognitive and personality characteristics. The data from the study showed that females were associated more with humanities characteristics. The study also indicated that “both teachers and students reported the perception that boys perform better in STEM disciplines, while girls perform better in humanities disciplines. Both boys and girls reported equally low familiarity with women role models presented in science courses” (Hand et al., 2017, p. 941). Additionally, their hypothesis was supported to conclude that both teachers and students “would show gender role biases by indicating that masculine characteristics are associated more highly with someone working in the sciences and that feminine characteristics are associated more highly with someone working in the humanities” (Hand et al., 2017, p. 935). Hand et al. further identified the teachers’ gender role biases by associating STEM
professionals more strongly with masculine cognitive characteristics and masculine personality characteristics. Furthermore, the results were influenced due to gender role bias misperceptions in today's society. In conclusion, the Hand et al. study found that gender bias factors have a significant effect on the perceptions of teachers and students and the main factors that contribute to gender bias in STEM education are the lack of role models outside of the classroom, self-efficacy, social bias, and social influence.

One final study worth mentioning is that of (Charlesworth & Banaji, 2019). Charlesworth and Banaji (2019) explored gender disparities in STEM fields to offer suggestions for remedying the issue. The first phase of the research used data from the National Science Foundation to create quantitative data that imply women remain underrepresented in computer science and engineering. “Strikingly, the representation of women has decreased in computer science, with female associate degrees dropping from 42% in 2000 to 21% in 2015, and the percentage of female bachelor's degrees dropping from 28% in 2000 to 18% in 2015” (Charlesworth & Banaji, 2019, p. 7239). The second phase of their research identified that the gender gap also causes a disparity in female representation in grants and publications. This phenomenon then continues to represent societal views of gender in STEM affecting underrepresentation of females in the STEM community. The third part concluded that “the current knowledge is presented on interventions to change individuals' beliefs and behaviors, as well as organizational culture and practices” (p. 7228). The study concluded that men and women reacted analogously when presented with confrontation biases. The researchers suggest that the gender gap persists due to implicit and explicit bias that shapes the perceptions of individuals. The solution presented by the researchers suggests that organization,
education, and businesses ensure that women are incorporated in STEM discoveries, technologies, and applications. Overall, the data from the three-part study concluded that gender gaps in STEM courses exist and STEM interest starts in early education; gender gaps are not decreasing in STEM education; and time cannot solve the gender gap. The representation of gender roles in society to promote a larger change in the current gender gap in STEM education and careers is needed.

Theoretical Framework

Two primary theories underpin the framework of this study. Bandura’s Social Cognitive Theory and Turiel, Smetana, and Nucci’s Social Domain Theory. Each will be explored further in the writing below.

Social Cognitive Theory

Social Cognitive Theory explains the environmental, behavioral, and personal factors that can influence high school female students in STEM education paired with stereotypes. The Social Cognitive Theory occurred in numerous studies reviewed when determining the influencing factors that affect student female choices in STEM education. Aligning to Bandura’s original theory, Oppong (2014) defines Social Cognitive Theory as “a triadic reciprocal determinism in which cognitive and other personal factors of behavior as well as environmental influences operate interactively as determinants of one another” (p. 113). Wang and Degol (2017) incorporated biological and social culture as an extension of the Social Cognitive Theory to describe the underrepresentation of women in STEM education. This includes teacher involvement by determining the proficiency skills required to reach a goal and the material being mastered in the class. Other studies have similar theories to explain the phenomenon by
exploring social interference when students are choosing between career paths or course selection. (Adelsberger, 2020) combined “Cognitive Evaluation Theory and Social Determination Theory to determine that students will be impacted by their environment and begin to process it internally, then assimilate their thought process to match” (p. 28). The research studies reviewed determined that social factors could change the mindset of the malleable brains of young students in STEM education (Adelsberger, 2020; Oppong, 2014; Riley, 2016; Wang & Degol, 2017).

This research study relates to the main factors of Social Cognitive Theory given that the research questions that drive the study will describe educators’ perceptions of gender bias, including factors that STEM educators perceive to influence female high school students participating in STEM education. Williams and Williams (2010) identified the relationship between self-beliefs and performance “endorses the notion of reciprocal determinism at a substantive–theoretical level” (p. 453). Reciprocal determinism includes three main components: behavior, individual, and environmental factors.

**Behavior factor.** Behavioral capabilities are taught through observational learning and can be learned through imitation and modeling. The behaviors are seen to change, determining the environment that they are in, including school or social norms of the community (Correll, 2001). Behavior relates to this study because female students’ attitudes can affect their perceptions on STEM education. Varma (2010) suggested that students who talked about behavior referred to boys being more rational and females being more emotional as an explanation for why males perform better in STEM activities. Hand et al. (2017) statistical analysis found that female students, from the perceptions of
teachers and students, were categorized with humanitarian roles and behavior. The past research corroborates that society has placed an unconscious bias that females lack STEM abilities and should prioritize family over career goals. This perception impacts academic achievement for females to pursue STEM education, even in high school (Grossman & Porche, 2014a). Social roles, stereotypes, and social influences each contribute to behaviors modeled in today’s society.

**Social roles.** Social roles that are considered the norm in society create unconscious choices that female students make not to choose STEM courses based on the general population's opinion (Wang & Degol, 2017). Studies have presented that society can influence an individual’s choice, even if the individual is not aware that the influence has taken place (Borg et al., 2017; Wang & Degol, 2017). “Adolescents internalize societal representations of different groups which shape their understanding of who individuals can be and what they can achieve” (Grossman & Porche, 2014b, p. 700). High school female students as well are highly influenced by social media and what others think about them, including overall reputation. Social influence can determine the path of a female high school student’s future. Findings of previous studies showed that society has placed specific social factors about gender that influence individuals’ behavior. Previous research reported that high school female students want to meet to fit into the predetermined social box that is expected (Cheryan et al., 2017; Master et al., 2016; Tsan et al., 2016; Xie et al., 2015). The outside influence can determine the conscious view that female high school students perceive towards STEM courses and future occupations.
**Stereotypes.** Studies confirmed that students have a stereotypical view of scientists where scientists are represented as “white males wearing lab coats, eyeglasses, with facial hair, and an eccentric appearance” (Thomson et al., 2019, p. 2). Masculinity is one stereotype that discourages women from participating in STEM education courses (Moss-Racusin et al., 2015; Robnett, 2016; Wang & Degol, 2017). The stereotype pushes away female students because they do not want to be associated with the stereotypical masculine appearance and social status that society associates with STEM occupations. Findings of previous studies showed that females were compared to traits like emotional, sensitive and nurturing, whereas male traits were compared to hardworking, strength and leadership (Cheryan et al., 2017; Master et al., 2016; Xie et al., 2015). The stereotypes that correlate with certain STEM careers then get categorized into the same category is suggested by the past research (Moss-Racusin et al., 2015; Robnett, 2016; Wang & Degol, 2017). Careers that are masculine are stereotypically seen by society as strong leadership positions held by men; this extends to STEM careers. Therefore, social norms deter females from wanting to be conceived as masculine resulting in less female representation in societal deemed masculine STEM professions.

**Social influences.** Social influence can determine the path of a female high school student’s future. The ideas from past research, determined through surveys and interviews, reflect that society has placed specific social factors about gender. Those social factors influence individuals’ behavior that high school female students who want to fit into the predetermined social box that is expected (Ellison & Vitak, 2015; Krezel & Krezel, 2017). Research supports that the current literature on the topic of student choice of higher education institution addresses “the processes of choice and implies the
relationship between social influence and student choice” (Chalcraft, Hilton, & Hughes, 2015, p. 117). Social influence has become more prevalent with technological advancements and students are constantly viewing material that can influence their opinions. The opinions gathered through social influence can create unknown biases or decisions on educational choices of high school students (Ellison & Vitak, 2015).

**Individual factors.** Personal factors include symbolized behavior, outcomes of behavior, learned behavior, self-determination, and reflection. Personal reflection is expressed through self-efficacy. Self-efficacy is related to this study because female high school students need to feel like they belong in the class to even consider continuing taking STEM education courses. Varma (2010) identified that female students talk about leaving the computing field primarily because of technical difficulties they face in the program, including anxiety. The study found that females did not feel like they belonged in the STEM careers and faced gender disparity in the workplace and educational organizations. Williams and Williams (2010) conducted a study using Bandura's reciprocal determinism to explore behavior, cognition, and environmental influences. The study concentrated on thirty-three nations with the participants being 15 years old and measuring self-efficacy in math. The self-efficacy equation (Machiavellianism, Gender, and SES) was used to compare the data. The study found that students who felt like they belonged in the class performed significantly higher in twenty-two nations (Williams & Williams, 2010). Self-efficacy and self-determination will be explored further in the next sections of writing.

**Self-efficacy.** Self-efficacy is based on an individual's belief in their own capacity to achieve in contrast to attitudes toward STEM that can be influenced by outside factors.
The qualities and skills are the ability-related measures that are prominent in other theories of motivation (Wigfield & Eccles, 2000). One example is the construct of self-efficacy in Bandura's Social Cognitive Theory. Bandura (1977) correlates self-efficacy to the importance of accomplishing the task successfully (attainment value), the usefulness of the task or domain relative to an individual's future (utility value), the enjoyment an individual gains when performing tasks of the domain (intrinsic value), and the cost of learning and acquiring competence (extrinsic value). Expectancies and values influence performance, persistence, and task choice. Domenech-Botoret et al. (2017) concluded that future academic choices can be predicted when individuals believe in their own abilities.

**Self-determination.** Self-determination in education is described as the intrinsic motivation for a specific interest that creates a higher quality of learning creating human satisfaction (Ryan & Deci, 2000). The Center for Psychology in Schools and Education states in 2015 “a substantial body of experimental research studies shows that extrinsic motivation, when properly used, is very important to producing positive educational outcomes” (p. 16). The research of Robnett (2016) concluded students that have intrinsic motivation in STEM courses have more interest and motivation to pursue STEM education more extensively. Self-determination must be supported by educators providing STEM course experiences that relate to the student and that the student learns for their own enjoyment (Xie et al., 2015).

**Environmental factors.** Environmental factors happen outside the person and can include family, friends, and peers at work, classmates, and social norms. “Physical environments will therefore also differ in the extent that they provide an effective milieu
for different types of social behaviors” (Meagher, 2020, p. 7). “Studies document that neighborhood disadvantage, commonly measured using such contextual variables as neighborhood-level poverty rate, affects children's cognitive ability” (Xie et al., 2015, p. 335). Therefore, as an environmental factor, social norms can influence the perception of females in STEM education both negatively and positively. This correlation contributes to the gender gap because “the society teaches children that men are supposed to take on the larger tasks, important tasks and women are supposed to take manageable tasks. Female students were conscious of the cultural role assigned to them” (Varma, 2010, p. 305). The influences of family/parental and educational factors will be discussed next.

**Family/parental factors.** There is a large amount of past research spanning decades on the effects of parents' social, education, and work level that predetermine their children's education and life outcomes (Ibe et al., 2018; Lui et al., 2020; Pinquart & Ebeling, 2020; Xie et al., 2015). Pinquart and Ebeling (2020) conducted a meta-analysis on concurrent and longitudinal associations between parental educational expectations and child achievement. They found that a stronger association with parental expectations with child achievement “in families of higher socioeconomic status and ethnic majority resulting in realistic expectations combined with resources to make the students' expectations reality” (Pinquart & Ebeling, 2020, p. 475). The weighted mean from the Pinquart and Ebeling study was consistent with the outcomes of previous meta-analysis from (Castro et al., 2015; Danişman, 2017; Jeynes, 2007; Tan, 2017). As noted by Tan (2017), educational opportunities because of parents’ ability to provide supplemental education or continuing education for students and their access to technology influences how females’ behavior and attitudes relate to STEM education. The research determined
that with parental influence, access to technology and educational choices more opportunities are available for students. These opportunities are then influenced by parental values and expectations for their children.

**Educational factors.** While most researchers will agree that parental involvement is a significant theory, other studies research theories on the activities and values of the student to determine the influence on educational choice and future aspirations (Legewie & DiPrete, 2014; Lykkegaard & Ulriksen, 2016; Sahin & Mohr-Schroeder, 2019). Legewie and DiPrete (2014) found that high schools’ curricula in science and math and gender segregation of extracurricular activities “have large effects on the gender gap in plans to study STEM fields, and these effects are robust to the subfields we use to define a STEM orientation” (p.16). Tsan et al. (2016) research found that early exposure to STEM courses even at the middle school level can increase positive attitudes towards STEM education resulting in increased STEM interest in high school female students’ courses in high school (Tsan et al., 2016). Educational opportunities combined with community and employment opportunities, therefore, contribute to what courses high school students take, which then can impact what career that student also chooses to pursue.

**Social Domain Theory**

Social domain theory relates to gender in the domain of gender development and childhood experiences that influence their decision-making skills in social settings. Building off the work of Nucci and Turiel (1978), Mulvey et al. (2010) explains how development of perceptions, knowledge, and beliefs about different social groups can create stereotyping and exclusion in adulthood. The term used in the literature is
cognitive categorizing. Research has been conducted on adult stereotyping on gender but there persists a gap in literature including stereotyping and exclusion on gender in childhood (Mulvey et al., 2010). While the individual is trying to fit into their social group, they perceive their status as positive which creates unconscious bias of other social groups (Peteraf & Shanley, 1997). This phenomenon starts at the development stage of childhood and continues through adult life. Experiences that children have create an encoding on the information and classify the information with stereotypic responses.

This research study relates to Social Domain Theory because children start at an early age categorizing groups for inclusion or exclusion based on social norms. The current research relates student choice on stereotypic social norms that are placed on STEM professions or courses that can influence female high school student’s choice on participating in the STEM pathway. When investigating student choice in past research, social norms and stereotypical notions about STEM careers were shown to have an impact on the choices that female high school students made when choosing a non-STEM pathway in education (Correll, 2001; Hand et al., 2017). The current study will describe educators’ perceptions on these influences to better understand how these factors influence STEM education participation. The research questions that drive this study will describe educators’ perceptions of gender bias, including factors that STEM education perceives to influence female high school students participating in STEM education eventually leading to the underrepresentation of females in STEM careers.

Chapter Summary

The literature review provided an understanding of previous research of gender bias in STEM education and the previous studies conducted to determine factors that
influence high school female students on STEM choice selection. Past research established that gender bias needs to be explored in greater detail to understand the underlying factors that contribute to the decrease in female high school enrollment in STEM education. The factors that were determined from past research included three main categories: behavioral, individual, and environmental. The categories provided evidence that influencing factors are complex and that individual choice can be determined at an early age by societal and family beliefs. These beliefs are then carried throughout the educational process and have been described to be influential in the underrepresentation of females in STEM education. The two main theories that investigate the perceptions pertaining to gender bias in STEM education are the Social Cognitive Theory and Social Domain Theory.
CHAPTER 3

METHOD

The purpose of this descriptive research study was to describe Skyler High School STEM education teachers' perceptions of factors that are influencing female high school students’ lack of interest and low participation in a STEM education. The research study is driven by the two research questions of the study.

1. What are high school STEM educators’ perceptions regarding gender bias in the STEM School of Study cluster at Skyler High School?
2. What factors do high school STEM educators perceive as contributing to low participation among female high school students in STEM courses?

Research Design

The research study followed an action research design. Action research is defined as any systematic inquiry conducted by teachers, administrators, counselors, or others with a personal stake in the teaching and learning process or environment for the purpose of gathering information about how their school operates, how they teach, and how their students learn (Mertler & Charles, 2011).

This research study is considered an action research study because of the four basic steps that were used to conduct the action research study: identifying an area of focus, collecting data, analyzing data, and interpreting the data, and developing an action plan for further (Mertler, 2017). Traditional research would not be appropriate for my study because the research is not trying to prove that influencing factors cause female
high school students to not pursue STEM careers but describe the perspectives of teachers on STEM bias in a specific population. Traditional research uses rigorous research designs to show a cause-effect relationship, whereas action research uses less controlled procedures to understand the effects of an educational intervention (Abdullayeva et al., 2019). The controlled procedures that were used in my research study included surveys and semi-structured interviews. Traditional research obtains knowledge that is generalizable to develop and test educational theories compared to action research that obtains knowledge that can be applied directly to the local classroom situation (Mertler, 2017). My research applied directly to STEM education regarding perceptions of gender bias, if any, by STEM educators to a specific population.

Characteristics of action research include: “immediate application, real problem solving at local locations, observing individuals or groups, using audio/video recordings, interviews and field notes to explore topics that relate to their educational issue being examined” (Abdullayeva et al., 2019, p. 146). Convergent parallel mixed method design was used because quantitative and qualitative data were collected at the same time. Creswell and Pablo-Clark (2011) define convergent parallel design as the “researcher concurrently conducts the quantitative and qualitative elements in the same phase of the research process, weighs the methods equally, analyzes the two components independently, and interprets the results together” (p. 8). My research collected quantitative and qualitative data in the same research phase. The data collected from the instruments was weighed equally to independently explain the results from the data collection methods.
The first step in the research process was to identify a specific area of focus. The area for this research was the underrepresentation of female high school students in STEM education that continues to female representation in STEM fields. My research described gender bias in STEM courses to determine if the phenomenon can be supported by the data outcomes that the research presents. Data collection included collecting quantitative and qualitative data from surveys, and semi-structured interviews. Multiple data analysis methods were used to describe the phenomenon. Antonenko (2015) defines descriptive research as “focused on portraying how education works by describing and interpreting phenomena related to teaching, learning, and performance” (p. 62). The research is applicable for a descriptive study because the research is describing and interpreting the phenomena of gender bias in STEM education. Action research provides a systematic process that allows the researcher to collect data on specific issues and compare the results to draw an overall conclusion (Mertler, 2009).

The last step of the action research was to develop an action plan and recommendations for further research. This last step was included in the findings and discussion sections of the research determined by the information that was described in the research study.

**Settings and Participants**

This action research study took place at a mid-size suburban high school in southeastern United States. The participants are high school STEM educators at Skyler High School. The site was selected because Skyler High School offers six STEM Programs for students to enroll in and receive Career and Technology Education (CATE),
AP or Dual-Enrollment credit. The courses are offered to students that are accepted into the program in 9th grade or students that are recommended by teachers to take AP courses. Information gathered from the Skyler High School website describes the STEM participants as teaching a range of intermediate, college preparatory, AP, and dual enrollment courses. The Skyler High School student population in 2021 is approximately 2586 with 183 faculty/staff. The school is diverse with seven ethnicities represented in the student population. 46% Caucasian, 34% African American, 13% Hispanic, 4% Multiracial, 4% Asian, 0.3% Native American, and 0.1% Pacific Islander.

The demographics included gender, years of teaching a STEM course(s), education level and age. Twenty STEM educators participated in the study. The demographics included gender, years of teaching a STEM course(s), education level and age. Twenty STEM educators participated in the study. The demographics of the educator participants of this study included 14 female and six males all with the ethnicity of white. The ages included 20-25 years old 10%, 26-30 years old 15%, 31-40 30%, 41-50 30% and 51-69 15%. Fifteen percent of participants’ highest level of education was a doctoral degree, masters plus 30 graduate hours 40%, masters 30%, and bachelors 15%. Of the STEM educators 30% have 20 or more years of experience, 10% 13-16 years of experience, 15% 9-12 years of experience, 25% 5-8 years of experience and 20% 1-4 years of experience. Only 15% of participants received additional certification to teach a STEM course. Six of the participants teach Science, six teach Mathematics, five teach another STEM category, and three teach technology.

A purposeful sample of seven was taken from the participants to conduct semi-structured interviews. Purposeful sampling was used to provide an “information-rich
selection related to the phenomenon of the study” (Palinkas et al., 2015, p. 1). The criteria for participating in semi-structured interviews included teaching a STEM course at Skyler High School, completion of the Perceptions of STEM Participant Survey, Sex Typing of Occupational Survey, and DASS. The inclusion criteria for the participants who were chosen for an interview were aligned as best as possible with the Skyler High School STEM demographics described.

Skyler High School is the largest high school in the area and is ranked 16th in SC for financial lunch assistance. The high school is located on a large campus with three wings, both upper and lower levels. The range of STEM classes that are offered at the school includes fundamental courses in STEM to Dual-Enrollment accreditation courses. Extracurricular activities for STEM that are available at the high school are Engineering Club, Chemistry Club, Science Bowl, and Gamer Club. Most students who participate in these extracurricular programs must be enrolled in specific STEM AP courses to qualify for acceptance into the extracurricular programs. There are six STEM programs, Career and Technology Education, Advanced Placement and Dual-enrollment credits at Skyler High School. Female participation in the extracurricular clubs is outshined by the female participants in Health Occupations Students of America (HOSA, also referred to as Future Health Professionals) and other medical societies offered by the Career and Technology campus.

Data Sources

To answer the research questions in the study, four data collection methods were used. Quantitative and qualitative data was collected, through surveys, observation, and
semi-structured interviews. Table 3.1 illustrates the alignment of the research questions to these data collection sources.

Table 3.1 Research Questions and Data Sources

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Data sources</th>
</tr>
</thead>
</table>
| RQ 1- What are high school STEM educators’ perceptions regarding gender bias in the STEM School of Study Cluster at Skyler High School? | • Perceptions of STEM Participant Survey  
• Draw A STEM Student  
• Sex Typing of Occupation Survey  
• Semi-Structured Interview |
| RQ 2- What factors do high school STEM educators perceive as contributing to low participation among female high school students within the STEM School of Study cluster at Skyler High School? | • Perceptions of STEM Participant Survey  
• Sex Typing of Occupations Survey  
• Semi-Structured Interview |

Surveys

Surveys were used in this study to measure perceptions of high school STEM teachers regarding gender bias and what they perceive as contributing to low female student participation in STEM courses at Skyler High School. “Surveys refer to a collective group of quantitative data techniques that involve the administration of a set of questions or statements to a sample of people” (Mertler, 2017, p. 144). The statistical data was recorded automatically then downloaded to a Microsoft Excel sheet for analysis. This online survey platform provided flexibility, accuracy, and efficiency (Lefever et al., 2007). Surveys were used in the research study because the study analyzed data gathered in the survey to attempt to understand the phenomenon and answer the research questions of the study.
**Perceptions of STEM Participant Survey.** The first quantitative data source, the Perceptions of STEM Participant Survey (see Appendix A), was distributed to participants using Google Forms. The Perceptions of STEM Participant Survey used in this study were adapted using a published, untitled, instrument from Londot’s (2018) questionnaire. The validity of the questionnaire was tested with test-retest methodology from seven expert educators to ensure validity and reliability of the instrument. The constructed questions were found valid. Table 3.2 shows the alignment between research questions and the Perceptions of STEM Participant Survey items.

Table 3.2 Alignment of Perceptions Survey Questions with Research Questions

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Perceptions of STEM Participant Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 1- What are high school STEM educators’ perceptions regarding gender bias in STEM School of Study Cluster at Skyler High School?</td>
<td>2. Gender is a contributing factor related to successful completion of a high school level STEM course. (Individual - Self-determination)</td>
</tr>
<tr>
<td></td>
<td>3. Female high school students lack the curiosity and experiences needed to be successful in STEM high school courses. (Environmental - Educational)</td>
</tr>
<tr>
<td></td>
<td>4. As compared to high school males, females should take more math classes to better be prepared for college level STEM courses.</td>
</tr>
<tr>
<td></td>
<td>5. High school female students’ personal life choices could prevent or alter successful enrollment or completion of high school STEM courses. (Individual – Self-Efficacy)</td>
</tr>
<tr>
<td></td>
<td>6. High school females have less support at home, as compared to males, to enter and successfully complete high school level STEM courses. (Environmental – Parental)</td>
</tr>
</tbody>
</table>
7. Females are less likely to work in computer science, physics, or mathematics careers compared to males’ choices could prevent or alter successful enrollment or completion of high school STEM courses. (Behavioral – Social)

8. Females are more successful in interactive science fields, such as the behavioral or medical fields.

10. High school females receive higher grades from female STEM teachers rather than from a male STEM teacher.

11. High school female students would benefit from taking additional math courses.

12. Female high school students should take advanced rigorous STEM courses in high school to better prepare them for college level STEM programs.

14. Female high school students are less likely to pursue a STEM pathway as compared to male students in high school.

<table>
<thead>
<tr>
<th>RQ 2</th>
<th>What factors do STEM educators perceive as contributing to low participation among female high school students in STEM courses?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Female students face significant biological and/or cultural barriers to successfully complete a high school level STEM program. (Environmental – Educational)</td>
</tr>
<tr>
<td>9.</td>
<td>Females need a different social environment than males, which creates challenges in competitive male dominated STEM paths. (Behavioral – Social)</td>
</tr>
<tr>
<td>13.</td>
<td>High school female students pursuing a STEM pathway would benefit from having a female STEM mentor. (Behavioral – Social Influences)</td>
</tr>
<tr>
<td>14.</td>
<td>Female high school students are less likely to pursue a STEM pathway as</td>
</tr>
</tbody>
</table>

36
The Perceptions of STEM Participant Survey described high school STEM teachers’ perceptions on female high school students' participation in STEM courses as well as explored the presence of gender bias. The Perceptions of STEM Participant Survey were cross-sectional. Cross-sectional surveys are used to take a snapshot of opinions at one point in time. Educators’ perceptions will be measured by the adapted Perceptions of STEM Participant Survey from Londot’s (2018) High School STEM Teacher Perceptions of Female Student Success: A Descriptive Study. Cronbach alpha was not reported in the research study. Permission was obtained from Londot to adapt and use the Perceptions of STEM Participant Survey (see Appendix B). The adaptations to the survey included replacing girls and boys to high school females and males. The survey was delivered electronically, and participants answered 14 statement questions. Participants responded to items such as “female students face significant biological and/or cultural barriers to successfully complete a high school level STEM program” and “gender is a contributing factor related to successful completion of a high school level STEM course” on a 5-point Likert scale 1 (strongly disagree) to 5 (strongly agree). One open-ended question was asked “in context to STEM programs and careers, where do STEM teachers perceive female high school STEM students in the future?” Demographic information was collected at the conclusion of the survey asking the participants gender, years of teaching STEM courses, education level, and age. The
Perceptions of STEM Participant Survey was given in August 2022 and the participants had a period of two weeks to complete, to run reliability analysis.

**Sex Typing of Occupations survey.** The second quantitative instrument used in the research study was Sex Typing of Occupation Survey (see Appendix C). This survey consisted of 27 items rated on a 7-point bipolar scale with the endpoints “masculine” and “feminine.” The survey consisted of occupations and asked the participant to respond if that occupation is a masculine occupation or feminine occupation from the participants’ perspective. The survey was distributed to the participants via email as a Google Form. The digital collection of data ensured prompt and accurate data collection. Quantitative data produced from the Sex Typing of Occupation Survey reflected perceptions of the participations to support an answer for research question one of this study. The Sex Typing of Occupation Survey used in this study is adapted from Kulik (1997) Sex Typing of Occupations original survey. The survey was adapted to replace the outdated occupations with 21st century occupations according to the U.S. Bureau of Labor Statistics database (BLS, 2020). See Appendix D for which occupations are perceived to be feminine, masculine, or gender neutral.

**Draw a STEM Student**

The DASS (see Appendix E) was adapted from the Draw a Scientist Instrument (Mead & Métraux, 1957) and produced both quantitative and qualitative data. The quantitative data was produced by assigning a score for the seven indicators from the original study. The participants received a digital Draw A STEM Student Google Doc that allowed the participants to draw on the Doc digitally. The participants also had the option to physically print the DASS and upload their drawing digitally.
The original Draw a Scientist instrument used seven types of indicators for data analysis: (1) lab coat, (2) eyeglasses, (3) facial growth of hair, (4) symbols of research, (5) symbols of knowledge, (6) technology products, and (7) taxonomic classification to analyze the drawings. A standard image to compare the images that participants drew was predetermined based on gender and each of the seven indicators (Schibeci & Sorensen, 1983). If the image the participants drew met an indicator criterion, a “score” was offered which produced outcomes that could be quantified. These same seven indicators and quantification of the drawings were used for this research study. The reliability of the Draw a Scientist Instrument was tested through an independent study by Schibeci and Sorensen (1983) who found the seven indicators to have “good” reliability ($\alpha=0.82$). Schibeci and Sorenson noted a limitation of their study that could impact their validity reporting included that the sample size of their population included only a small group of participants ($n=23$). Consistent with the Draw a Scientist instrument, the DASS asked the participants to respond to three open-ended questions: describe what the student is doing in the picture, list three words that come to mind when you think of this STEM student, and what kinds of things do you think this student does on a typical day? List at least three things. Qualitative data generated from the participants responses. “An open-ended question allows the respondent to answer in any way he or she wishes, that is, an open-ended response” (Devlin, 2017, p. 141). The findings of the DASS were used to support and answer both research questions of this study.
Semi-Structured Interviews

The semi-structured interview questions were open-ended to describe individual experiences and perceptions (see Appendix F). “The advantages of semi-structured interviews are that they follow for more emic, emergent understandings to blossom, and for the interviewees’ complex viewpoints to be heard without the constraints of scripted questions” (Tracy, 2020, p. 158). The interview questions are aligned to answer both research questions (see Table 3.3). Another advantage of semi-structured interviews as a qualitative data source is they “allow the researcher the flexibility to probe initial participant responses – that is, to ask why or how” (Mack, Woodsong, MacQueen, Guest, & Namey, 2005, p. 4). Semi-structured interview guides are less formal and allow more flexibility and create a collaborative dialogue (Tracy, 2020). The eight interview questions used in this study were reviewed and critiqued by my dissertation chair to assure wording accuracy and alignment with the research questions of the study. The data produced from the seven semi-structured interviews allowed the participants' perceptions and voice to be reflected in narrative writing of the results (Purvis et al., 2017; Sutton & Austin, 2015). The interviews were conducted from 30-45 minutes with time for the participant to ask questions. Seven participants were selected, using simple random sampling, to participate in the semi-structured interviews.

Table 3.3 Alignment of Semi-Structured Interview Questions with Research Questions

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Research questions (Reciprocal Determinism Factor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 1- What are high school STEM educators’ perceptions regarding gender bias in STEM courses?</td>
<td>4. Gender stereotyping means an overgeneralization of traits, differences and qualities based on gender. Share with me</td>
</tr>
</tbody>
</table>
what you think about gender stereotyping in STEM areas? (Behavior)

a. (Follow up) What are your perceptions for why females at Skylar High School take more AP health science track courses or enroll in HOSA (Future Health Professionals) and other medical societies offered by the Career and Technology campus.

5. Let’s talk briefly about curriculum bias, meaning real or perceived bias in the educational curriculum involving diverse, equitable, and inclusive examples. What is your perception about curriculum bias influencing females at Skylar HS from participating in STEM courses? (Environmental)
   a. (If yes) At, what grade do you think curriculum bias is present?

7. What do you perceive needs to change during the recruitment of middle school females into the Skyler High School STEM education program? (Environmental)
   a. (Follow up) What do you think could be improved upon to better support female interest in taking STEM courses?

RQ 2- What factors do STEM educators perceive as contributing to low participation among female high school students in STEM courses?

1. What social norms, if any, do you perceive to affect the enrollment of high school female students in STEM courses? (Behavior)
   a. What are your thoughts about societal pressures, if any, that influence the decision-making of high school female students in taking STEM courses?
2. Share with me an example about how societal pressures, if any, influence the decision-making of high school female students in taking STEM courses? (Behavior)

3. What are your perceptions, if any, about gender stereotyping in the STEM areas? (Behavior)
6. What is your perceptions about the influence of female self-efficacy in STEM occupations? (Individual)
7. What do you perceive needs to change during the recruitment of middle school females into the Skyler High School STEM education program? (Environmental)
   a. (Follow up) What do you think could be improved upon to better support female interest in taking STEM courses?
8. Share with me what you perceive to be the biggest barrier for why females at Skyler High School do not enroll in STEM courses? (Individual, Environmental, Behavior)
   a. (Follow up) Why do you believe is a barrier?

Data Analysis

In this mixed-methods study four sources of data were analyzed: (1) Perceptions of STEM Participant Survey, (2) DASS Instrument, (3) Sex Typing of Occupations survey, and (4) semi-structured interviews. The alignment among the proposed research questions, data sources, and data analysis methods is depicted in Table 3.4.
Table 3.4 Research Questions, Data Sources, and Data Analysis Methods Alignment

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Data sources</th>
<th>Data analysis methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1- What are high school STEM educators’ perceptions regarding gender bias in the STEM School of Study Cluster at Skyler High School?</td>
<td>• Perceptions of STEM Participant Survey • Draw A STEM Student instrument • Sex Typing of Occupations Survey • Semi-structured Interviews</td>
<td>• Descriptive Statistics • Inductive Analysis</td>
</tr>
<tr>
<td>RQ2- What factors do high school STEM educators perceive as contributing to low participation among female high school students in STEM courses?</td>
<td>• Semi-structured Interviews • Perceptions of STEM Participant Survey</td>
<td>• Descriptive Statistics • Thematic Analysis</td>
</tr>
</tbody>
</table>

Descriptive statistics were calculated to determine the mean and standard deviation of the responses, referred to as the measure of central tendency (Mertler, 2017), “measures of central tendency are statistical procedures that indicate, with a single score, what is typical or standard about a group or individuals” (p.180). The statistical data was run using Microsoft Excel to perform descriptive analysis. Descriptive statistics were used to analyze the quantitative data, including a reliability analysis being conducted on the Perceptions of STEM Participant Survey results to run reliability analysis. Inductive analysis was used to analyze qualitative data to collect relevant data to the topic of research.

The DASS included seven standardized indicators to look for in the drawings by the participants. An excel sheet was created to capture if each indicator is found (or not) in the drawings by the participants. Descriptive statistics were used to determine the
frequencies of the indicators found in the artifact or drawings from the participants.

“Artifacts include any object made by humans (handmade or manufactured) or a natural object that can be touched or handled” (Saldaña & Omasta, 2022, p. 64). The quantitative results contributed to the outcomes about STEM teachers' perceptions on high school females' lack of enrollment, if any, in STEM classes as well as any perceived gender bias, if present.

Qualitative data was gathered from semi-structured interviews, the open-ended question on the Perceptions of STEM Participant Survey and drawing artifacts from the participants for the DASS. Prior to a qualitative analysis taking place, the semi-structured interviews were transcribed and provided to the participants to affirm their transcription aligns with what they recall being shared. The combined qualitative data text was reviewed multiple times to become familiar with the text as well as review for accuracy. The data was analyzed to find recurring themes and perceptions that STEM educators have on gender bias in STEM education. This process is referred to as thematic analysis that identifies, analyzes, organizes, describes, and reports to the themes found in the data (Nowell et al., 2017). Inductive analysis starts with gathering detailed information from the participants and then forms categories or themes from the patterns, theories or generalizations that compare the personal experiences or existing literature on the topic” (Creswell & Creswell, 2018, p. 63). With all qualitative data sources combined, process coding was conducted as a part of the inductive analysis process. “Process coding is appropriate for all forms of qualitative data, and particularly for studies that search for routines and rituals of human life and the action and reactions that occur as we deal with conflicts or problems to solve” (Saldaña & Omasta, 2016, p. 79). Four cycles of coding
were completed to identify participants' experiences accurately descriptive coding, process coding, in vivo coding and value coding. Delve, an online coding program, was used to extract notable comments from the transcripts into a table. After coding, the codes were condensed into categories and then further reduced into themes; themes that have emerged out of the coding process. The codes and emerging themes found in the data analysis were included in a table. All data sources were triangulated to best answer both research questions.

**Procedures and Timeline**

The study consisted of three phases: Phase 1: Consent; Phase 2: Data Collection; and Phase 3: Data Analysis. The study took place over the course of summer and fall 2022 semesters. Table 3.5 below summarizes the timeline of the procedures by phase, activity, and duration for the study.

**Phase 1: Consent**

Phase one was conducted over a 12-week period. The first step consisted of obtaining approval from the University of South Carolina IRB. The IRB approval process was four weeks. The approval from the district was four weeks. Once approved, an email was constructed by the researcher and then distributed by the district office personnel requesting all high school STEM teachers to participate in the dissertation research study on August 15, 2022. In this email communication, the research topic, purpose, and process were explained with an invitation to contact the researcher if STEM educators had questions. A second email was constructed by the researcher and distributed by district office personnel on August 20th, 2022, requesting additional participants.
Informed written consent forms were obtained from the interested participants (see Appendix G). A time of four weeks was allotted for the informed consent to be obtained from the individuals. The timeline for Phase 1 is displayed in Table 3.5 below.

Table 3.5 Timeline for Procedures

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activity</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Consent: IRB Approval</td>
<td>• Obtain University of South Carolina IRB approval and school district approval.</td>
<td>12 weeks</td>
</tr>
<tr>
<td></td>
<td>• Inform participants of topic, purpose, and process.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Obtain written informed consent from participants.</td>
<td></td>
</tr>
<tr>
<td>2: Data Collection</td>
<td>• Distribution of Perceptions of STEM Participant Survey.</td>
<td>8 weeks</td>
</tr>
<tr>
<td></td>
<td>• Distribution of Draw A STEM Student Instrument.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Distribution of Sex Typing of Occupation Survey.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Conduct Semi-structured interviews.</td>
<td></td>
</tr>
<tr>
<td>3. Data Analysis</td>
<td>• Analysis of the quantitative and qualitative data.</td>
<td>8 weeks</td>
</tr>
<tr>
<td></td>
<td>• Member checking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sharing results</td>
<td></td>
</tr>
</tbody>
</table>

Phase 2: Data Collection

The data collection phase consisted of an 8-week period that allocated sufficient time for participation in the study. During this time four data collection processes were
administered. The first, second, and third data collection instruments were sent electronically through the district’s secure Google Email Suite as a Perceptions of STEM Participant Survey, Draw A STEM Student, and Sex Typing of Occupation Survey, distributed by the Google Forms application. Google Forms automatically collected the data and was downloaded to code the information gathered. The second instrument utilized the application Google Draw for participants to submit their response. The participants also had the option to upload a secure file to the Google Form Perceptions of STEM Participant Survey. The data collection process for the three data collection instruments took place over a two-week period. Week three began data collection from semi-structured interviews. The interviews were scheduled for each participant over a five-week period. The interviews were conducted in a secure and private room at the researcher’s location. A predetermined interview protocol and script was created. The interviews lasted approximately 35-45 minutes and were recorded.

**Phase 3: Data Analysis**

Data Analysis was the final phase of the study and spanned over an 8-week period. Member checking was conducted by the participants of the study. The participants were asked to review the transcripts from their semi-structured interviews to ensure credibility and trustworthiness of the study. Descriptive statistics were used to summarize and validate the data from the perceptions survey. Two parametric tests, an ANOVA and chi-square, will offer additional depth of the Perceptions of STEM Participant Survey’s quantitative findings. The Draw of a STEM Student responses were analyzed qualitatively by analyzing the pictures to identify stereotypical gender related characteristics of the drawing. The Sex Typing of Occupation Survey had a
predetermined list of feminine, masculine and gender-neutral occupations. The data was compared to the chart and the participants' answers that were collected, including descriptive statistics. The semi-structured interviews were transcribed and coded using inductive analysis to describe the emergence of themes out of the qualitative data. The findings from the quantitative and qualitative data sources were merged to best support answers to the research questions of this study.

The preliminary results were shared with my dissertation committee during my final oral defense of my dissertation research. The data was then shared with school’s stakeholders, peers, and at local and state STEM conferences, such as SC EdTech Conference.

Rigor & Trustworthiness

Multiple research methods were used to describe STEM educators’ perspectives on gender bias in STEM courses and ensured rigor and trustworthiness of the research study. The rigor and trustworthiness methods include: (a) triangulation, (b) peer debriefing, (c) member checking, and (d) thick, rich descriptions. The methods will be described below, including how the method helped the research study and how the method was used, specifically in the research.

Triangulation

Triangulation was used in the study to increase the credibility and validity of the research findings by using multiple sources of data or multiple approaches to analyzing data (Noble & Heale, 2019). Triangulation is seen through the lens of researchers from evidence collected and researcher reflexivity (Creswell & Miller, 2000). In this study the triangulation was completed by examining the qualitative data from interviews and open-
ended questions from surveys. Triangulation gave a voice to the participants and research from different points of view that described the phenomenon in more detail.

Methodological triangulation design was used by collecting quantitative and qualitative data to describe a more holistic perspective of the research problem. “The rationale for this approach is that the quantitative data and their subsequent analysis provide a general understanding of the research problem” (Creswell, 2014, p. 264). Quantitative data was collected from the closed-ended questions collected from the Perceptions of STEM Participant Survey, DASS, and Sex Typing of Occupation survey. Qualitative data was collected from open-ended questions asked in the semi-structured interviews and three open-ended questions pertaining to the participants drawing from the DASS that elaborated on the statistical findings from the quantitative data. The perspectives of gender bias in STEM courses were collected from the variables, constructs and concepts of the instruments used in the study. The perceptions of the participants were explored more in depth to explain the phenomenon of gender bias from the STEM educators’ perspectives in STEM education. The quantitative and qualitative data were weighted equally in the study due to the importance of each data set answering the two research questions. The data was merged in the interpretation phase of the research through merging data sets to explore the variables during the data analysis phase (Creswell, 2014). Internal validity is concerned with “the congruence of the research finding with reality” (Zohrabi, 2013, p.258).

Peer Debriefing

Lincoln and Guba (1985) define peer debriefing as a "process of exposing oneself to a disinterested peer in a manner paralleling an analytic session and for the purpose of
exploring aspects of the inquiry that might otherwise remain only implicit within the inquirer's mind" (p. 308). Peer debriefing was used in the study by seeking advice from the dissertation committee members. The members read the research findings and determined the accuracy of the account. Peer debriefing was used to “enhance the accuracy and validity of the account by involving an interpretation beyond the research” (Creswell & Creswell, 2018, p. 201). Peer debriefing enhances the account of the accuracy of the findings by restricting bias interpretation of the information. My dissertation chair provided peer debriefing. Additionally, through virtual meetings with my cohort classmates, they provided peer review feedback of my study and provided a larger worldview about the study and its findings.

**Member Checking**

“Member checking is used to validate, verify, or assess the trustworthiness of qualitative results” (Birt et al., 2016, p. 1802). The researcher in this study provided the participants with the transcript of their semi-structured interview. The participants then confirmed the content of the transcript is true to their responses from the interview. Member checking ensures that I, the researcher, understands the subject's voices and I am correctly interpreting their voices. Lincoln and Guba (1985) consider member checking to be the "single most important provision that can be made to bolster a study's credibility" (p. 314). By conducting member checking with the participants, the data from the interview instrument was given plausibility and truthfulness by discussing accuracy of data and finding with the participants (Carlson, 2010). Nowell et al. (2017) identified “member checking, as a last step, allows the researcher to establish the fit between respondents’ views and the researcher’s representation of them” (p. 11). The member
checking allowed the researcher to check what was interpreted to be accurate and to share the themes with the participants. Direct quotes from the participants' transcripts were included in the writing of this research to add credibility to the study.

**Thick, Rich Descriptions**

A thick, rich description of the intervention is described in the settings and participants section of this research study (Tracy, 2020). The thick, rich descriptions contextualized the meanings of the specific population that was being researched to transport the readers to the setting for a shared experience (Creswell, 2014). Descriptions will help the reader see the study and add to the rigor and trustworthiness of the study (Tracy, 2020). Uses of thick, rich descriptions in this study include describe the setting, the participants, and the themes that emerged out of the data in great detail to allow the reader to experience the statements that are produced by the study to establish credibility through the lens of the reader (Creswell & Miller, 2000). When the themes of qualitative research are presented, they will describe in detail the realistic findings of the research. The goal is to provide “a shared experience for the researcher, the participants, and the reader” (Creswell, 2014, p. 200). This study used thick, rich descriptions, including quotations from the participants, to provide sufficient details about the STEM educators’ perspectives on gender bias in STEM education.

**Plan for Sharing & Communicating Findings**

**Stakeholders**

The study's findings were critiqued by my dissertation committee at the University of South Carolina Columbia to verify that the study meets all standards for graduate-level dissertation standards and ethics. The findings of this action research were then shared in
a presentation with the STEM educator participants and additional stakeholders at

different community levels of the district in which the study is taking place. The research
findings were shared with Skyler High School Dean of STEM education, STEM teachers,
principals, and the Superintendent of Curriculum. The presentation showed the findings
of STEM educator perceptions on gender bias in STEM education at Skyler High School.
As well, the presentation will reveal the STEM educators' perceptions of what
contributing factors are resulting in lower female enrollments in STEM courses at Skyler
High School.

**STEM Education Peers**

“Peer Review is defined as a process of subjecting an author’s scholarly work,
research or ideas to the scrutiny of others who are experts in the same field” (Kelly et al.,
2014, p. 228). A presentation of the findings will be presented to the SC EdTech
committee and South Carolina’s Coalition for Mathematics and Science. The importance
of sharing data within the field of STEM is to inform the community of the research
findings of the phenomena. “Data sharing is a valuable part of the scientific method
allowing for verification of results and extending research from prior results” (Tenopir et
al., 2011, para. 1). Peer sharing creates credibility for the research and recognizes the
significance of the study by sharing with peers in your field of study.
CHAPTER 4
ANALYSIS AND FINDINGS

The purpose of this action research was to describe STEM educators' perceptions pertaining to gender bias in STEM education, including factors that STEM educators perceive to influence low participation of female high school students in STEM education. The two research questions are answered with quantitative and qualitative data analysis. The two research questions are: (1) What are high school STEM educators’ perceptions regarding gender bias within the STEM School of Study Cluster at Skyler High School and (2) What factors do high school STEM educators perceive as contributing to low participation among female high school students within the STEM school of study cluster at Skyler High School? The chapter exhibits the analysis and findings from the data collected from the Perceptions of STEM Participation Survey, Draw a Student instrument and semi-structured interviews by the STEM educators. The chapter includes (a) quantitative analysis and findings and (b) qualitative analysis and findings.

Quantitative Analysis

Quantitative data collected in the study include participants’ responses to the (a) Perceptions of STEM Participation Survey, (b) Sex Typing Occupation Survey, and (c) DASS Instrument. This section includes the method of analysis and findings for each instrument. The data analysis was collected via Google Forms and forms and downloaded to Microsoft Excel. All data was analyzed in Microsoft Excel. Unless otherwise noted, for all statistical tests, an alpha level of .05 was used to determine significance (Mertler, 2021).
The Perceptions of STEM Participation Survey (see Appendix A) was adapted from a questionnaire used by Londot (2018) as described in Chapter 3. The survey assessed high school STEM educators’ perceptions of female high school students’ participation in STEM courses as well as explored the presence, if any, of gender bias in STEM courses. The Perceptions of STEM Participation Survey included 14 statements and participants' responses were scored on a 5-point Likert scale, 1 (strongly disagree) to 5 (strongly agree). To check the content validity, two experienced colleagues at USC-Columbia reviewed the instrument and provided feedback regarding specific instrument items. Conducting the Cronbach alpha (Cronbach, 1951; Tavakol & Dennick, 2011) test revealed there to be a good reliability, or internal consistency of the Perceptions of STEM Participation Survey ($\alpha = .88$).

Descriptive statistics. “Descriptive statistics are simple mathematical procedures that serve to simplify, summarize and organize relatively large amounts of numerical data” (Mertler, 2021, p.180). Using descriptive statistical analysis of the data for this research was appropriate because the research questions were trying to describe the collective group of participants in the study. The mean score of responses on the Perceptions of STEM Participation Survey was 2.75 (SD = 1.03). Table 4.1 shows the descriptive statistics for each statement on the Perceptions of STEM Participation Survey. The overall mean score on the Perceptions of STEM Participation Survey suggests that high school STEM educators were between a slight disagreement to being neutral about the statements presented concerning female high school students’ participation in STEM courses.
Table 4.1 Descriptive Statistics of the Perceptions of STEM Participation Survey (N =20)

<table>
<thead>
<tr>
<th>Statement</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Female students face significant biological and/or cultural barriers to</td>
<td>2.40</td>
<td>1.14</td>
</tr>
<tr>
<td>successfully complete a high school level STEM program.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Gender is a contributing factor related to successful completion of a</td>
<td>2.25</td>
<td>1.16</td>
</tr>
<tr>
<td>high school level STEM course.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Female high school students lack the curiosity and experiences needed</td>
<td>1.95</td>
<td>1.05</td>
</tr>
<tr>
<td>to be successful in STEM high school courses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. As compared to high school males, females should take more math classes</td>
<td>1.80</td>
<td>0.89</td>
</tr>
<tr>
<td>to better be prepared for college level STEM courses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. High school female students’ personal life choices could prevent or</td>
<td>3.10</td>
<td>1.17</td>
</tr>
<tr>
<td>alter successful enrollment or completion of high school STEM courses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. High school females have less support at home, as compared to males,</td>
<td>2.60</td>
<td>1.23</td>
</tr>
<tr>
<td>to enter and successfully complete high school level STEM courses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Females are less likely to work in computer science, physics, or</td>
<td>2.80</td>
<td>1.06</td>
</tr>
<tr>
<td>mathematics careers compared to males.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Females are more successful in interactive science fields, such as the</td>
<td>3.05</td>
<td>0.69</td>
</tr>
<tr>
<td>behavioral or medical fields.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Females need a different social environment than males, which creates</td>
<td>2.55</td>
<td>0.94</td>
</tr>
<tr>
<td>challenges in competitive male dominated STEM paths.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. High school females receive higher grades from female STEM teachers</td>
<td>2.25</td>
<td>1.02</td>
</tr>
<tr>
<td>rather than from a male STEM teacher.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. High school female students would benefit from taking additional math</td>
<td>3.20</td>
<td>1.28</td>
</tr>
<tr>
<td>courses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Female high school students should take advanced rigorous STEM courses</td>
<td>3.85</td>
<td>0.93</td>
</tr>
<tr>
<td>in high school to better prepare them for college level STEM.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. High school female students pursuing a STEM pathway would benefit from</td>
<td>3.80</td>
<td>0.95</td>
</tr>
<tr>
<td>having a female STEM mentor.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Female high school students are less likely to pursue a STEM pathway</td>
<td>2.85</td>
<td>0.933</td>
</tr>
<tr>
<td>as compared to male students in high school.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sex Typing Occupation Survey

The Sex Typing Occupation survey (see Appendix B) was adapted from the Kulik (1991) Sex Typing Occupations Survey as described in Chapter 3. The occupations of the Sex Typing Occupation Survey used in this study were updated to represent 21st century occupations according to the U.S. Bureau of Labor Statistics database (BLS, 2020). Only 14 of the 19 participants of this study completed the Sex Typing Occupation Survey instrument. The survey consisted of 27 items and participants were to provide a response based on a 7-point bipolar scale with the endpoints of 1 indicating “masculine” and 7 indicating “feminine”. The Cronbach’s alpha (Cronbach, 1951; Tavakol & Dennick, 2011) was used to measure the reliability or internal consistency of the participants' responses on the Sex Typing Occupation Survey. Cronbach’s alpha reliability is the most widely used measure for reliability to describe the sum of questionnaire items (Bonett & Wright, 2015). The Cronbach alpha test revealed there to be an excellent reliability, or internal consistency, of the Sex Typing Occupation survey responses (a = 0.95).

Descriptive statistics. Descriptive statistics was conducted on the Sex Occupation Survey data to collect, display, analyze, and draw conclusions from the data (Schafer & Zhang, 2012). The mean is used to determine the average of a data set and the underlying structure of the data (Griffith & Friesen, 2021; Schafer & Zhang, 2012). Figure 4.1 displays the mean score and standard deviation of the responses from the Sex Occupation Survey to show the relationship between the occupations and what the STEM educators perceived the gender to be for a person filling that occupational role.

The overall mean score of responses on the Sex Typing Occupation Survey was 3.79 (SD = 0.84). The top four occupations where the mean scores were found to
represent a feminine occupation were Dental Hygienist \( (M = 5.93, SD = 1.14) \), Certified Nursing Assistant \( (M = 5.43, SD = 0.85) \), Registered Nurse \( (M = 5.29, SD = 0.99) \), and Physician Assistant \( (M = 5.00, SD = 0.78) \). The top four occupations where the mean scores were found to represent a masculine occupation were Waste Management \( (M = 2.07, SD = 0.99) \), Land Surveyor \( (M = 2.64, SD = 0.84) \), Air Traffic Controller \( (M = 2.71, SD = 0.91) \), and IT Manager \( (M = 2.71, SD = 0.99) \). The top four occupations where the mean scores were found to represent a gender-neutral occupation were Computer Support Specialist \( (M = 3.50, SD = 0.85) \), Chemist \( (M = 3.50, SD = 0.52) \), Statistician \( (M = 3.43, SD = 0.76) \), and Architect \( (M = 3.36, SD = 0.84) \). Figure 4.1 displays the descriptive statistics for the Sex Typing Occupation Survey.

<table>
<thead>
<tr>
<th>Feminine Occupations</th>
<th>Masculine Occupations</th>
<th>Gender Neutral Occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental Hygienist ( (M = 5.93, SD = 1.14) )</td>
<td>Waste Management ( (M = 2.07, SD = 0.99) )</td>
<td>Computer Support Specialist ( (M = 3.50, SD = 0.85) )</td>
</tr>
<tr>
<td>Certified Nursing Assistant ( (M = 5.43, SD = 0.85) )</td>
<td>Land Surveyor ( (M = 2.64, SD = 0.84) )</td>
<td>Chemist ( (M = 3.50, SD = 0.52) )</td>
</tr>
<tr>
<td>Registered Nurse ( (M = 5.29, SD = 0.99) )</td>
<td>Air Traffic Controller ( (M = 2.71, SD = 0.91) )</td>
<td>Microbiologist ( (M = 4.00, SD = 0.88) )</td>
</tr>
<tr>
<td>Physician Assistant ( (M = 5.00, SD = 0.78) )</td>
<td>IT Manager ( (M = 2.71, SD = 0.99) )</td>
<td>Zoologist ( (M = 3.94, SD = 0.62) )</td>
</tr>
<tr>
<td>Radiologic Technologist ( (M = 4.9, SD = 0.80) )</td>
<td>Orthodontist ( (M = 2.79, SD = 1.05) )</td>
<td>Forensic Scientist ( (M = 3.86, SD = 0.36) )</td>
</tr>
<tr>
<td>Teacher ( (M = 4.64, SD = 0.74) )</td>
<td>Mechanical Engineer ( (M = 2.86, SD = 0.86) )</td>
<td></td>
</tr>
<tr>
<td>Medical Laboratory Technician ( (M = 4.57, SD = 0.65) )</td>
<td>Computer Programmer ( (M = 2.87, SD = 0.95) )</td>
<td></td>
</tr>
<tr>
<td>Treasurer ( (M = 4.50, SD = 0.85) )</td>
<td>Dentist ( (M = 3.00, SD = 1.18) )</td>
<td></td>
</tr>
<tr>
<td>Psychologist ( (M = 4.43, SD = 0.85) )</td>
<td>Network Administrator ( (M = 3.07, SD = 0.62) )</td>
<td></td>
</tr>
<tr>
<td>Oceanographer ( (M = 4.63, SD = 1.0) )</td>
<td>Statistician ( (M = 3.44, SD = 0.76) )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Architect ( (M = 3.36, SD = 0.84) )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aeronautics ( (M = 3.19, SD = 0.83) )</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.1 Descriptive Statistics for the Sex Typing Occupation Survey \( (N = 14) \). Score of 1 represented masculine occupation, score of 7 represented feminine occupation.

The DASS Instrument included the question “List three words that come to mind when you think of this STEM student.” The descriptive statistical analysis of a frequency count was again used to analyze the words provided by the participants. Fifty-five words were identified by 13 participants, with 45 words being unduplicated (see Table 4.2). Of the 45 unique words, “studious” was reported the most (4) by four different participants. There were seven words used by more than one participant: studious, intelligent, creative,
determined, drive, inquisitive, and problem solver. Words that were synonymous were combined into one dominant word with the according frequency count to create ten overarching word categories that participants used to describe a STEM Student (Table 4.2). For example, the participants offered the words creative (2), curious (1), initiative (1), and innovative (1). These four words and the frequency count for each word were combined into one category word of “Creative” with a frequency count of five. Two-word categories produced the same frequency count of ten: Dedicated (10) and Intelligent (10). Words used to form the Dedicated word category were determined (2), driven (2), dedicated (1), dedicated to task (1), focused (1), motivated (1), focused (1), and working (1). Words used to form the Intelligent word category were confident (1), intelligent (3), observant (1), smart (1), and studious (4).

Table 4.2 Frequency of Words Describing a STEM Student (N=13)

<table>
<thead>
<tr>
<th>Categories</th>
<th>Word</th>
<th>Total Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Subject Analyzer</td>
<td>analyzer, analytical, calculating, evaluating, methodological, thorough</td>
<td>6</td>
</tr>
<tr>
<td>Creative</td>
<td>creative (2), designing, exploring, initiative, innovative</td>
<td>6</td>
</tr>
<tr>
<td>Dedicated</td>
<td>committed, dedicated to task, determined (2), driven (2), focused,</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>motivated, passionate, working</td>
<td></td>
</tr>
<tr>
<td>Intelligent</td>
<td>confident, diligent, intelligent (3), smart, studious (4)</td>
<td>10</td>
</tr>
<tr>
<td>Introverted</td>
<td>introverted, quiet, safe</td>
<td>3</td>
</tr>
<tr>
<td>Kinesthetic learner</td>
<td>hands-on learning, kinesthetic learner</td>
<td>2</td>
</tr>
<tr>
<td>Problem Solver</td>
<td>inquisitive (2), problem solver (2), testing, thinker, thinking</td>
<td>7</td>
</tr>
<tr>
<td>Researching</td>
<td>curious, experimental, implementing, observant, researcher, researching</td>
<td>6</td>
</tr>
<tr>
<td>Stressed</td>
<td>careful, precise, stressed</td>
<td>3</td>
</tr>
</tbody>
</table>
Figure 4.2 was created with an internet tool WordItOut (worditout.com) to reflect the word frequency of responses from the participants. The software generates a cloud of words to display the most frequently used word in a larger font and differentiates the word frequency with different font color (Saldaña, 2021).

Finally, the DASS Instrument also included two open-ended questions added to the qualitative data analyzed.

**Qualitative Analysis**

Qualitative data in this action research study was used to give real viewpoints of educators’ perceptions of females in STEM education. The qualitative data sources in the
study included three open-ended survey questions and seven semi-structured interviews. The three open-ended survey questions were collected from two sources: the Perceptions of STEM Participant Survey and Draw A STEM Student. Twenty participants responded to the Perceptions of STEM Participant Survey and 13 participants responded to the Draw A STEM student open-ended questions. Inductive analysis was used to reduce the volume of information that was collected to organize and present the key findings of the study (Burnard et al., 2008). The inductive analysis was conducted by reading through the data, coding the data, then allowing patterns, categories, and themes to emerge (Miles, Huberman, & Saldaña, 2020). Specifically, four rounds of first cycle coding methods were completed, Descriptive Coding, Process Coding, In Vivo Coding, and Value Coding. Upon completing the first cycle coding, a total of 335 codes were generated (see Table 4.3). The second cycle coding method used was Pattern Coding which produced six categories that led to the emergence of three themes.

Table 4.3 Summary of Qualitative Data Sources

<table>
<thead>
<tr>
<th>Qualitative Data Sources</th>
<th>Number of Sources</th>
<th>Number of Codes Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptions of STEM Participant Survey</td>
<td>1 open-ended questions</td>
<td>40</td>
</tr>
<tr>
<td>Draw A STEM Student</td>
<td>2 open-ended questions</td>
<td>20</td>
</tr>
<tr>
<td>Semi-Structured Interviews</td>
<td>6</td>
<td>275</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>335</td>
</tr>
</tbody>
</table>

The semi-structured interview transcripts were recorded using the online Google Meet video recording application in conjunction with the online transcription application Otter to transcribe the semi-structured interviews and check for accuracy. Each person interviewed was given a pseudonym to protect the privacy of their information shared. Member checking was used to determine the accuracy of the semi-structured interview
transcripts by having each participant review the transcripts. A printed copy of each individual participants’ transcript was provided for the participant to review. Member checking was conducted by sharing the themes and findings of the study with the participants. The participants did not provide any changes to their interview transcripts. The qualitative data from the Perceptions of STEM Participation Survey, DASS Instrument, and semi-structured interviews were then uploaded into the online qualitative tool Delve. The data was then analyzed using a sentence-by-sentence unit of analysis to capture important data shared from the participants that ultimately were used to answer the two research questions of this study (Saldaña, 2016).

First Cycle Coding

The first method of coding used in this qualitative data analysis was Descriptive Coding. Saldaña (2021) defines Descriptive Coding as a process that creates codes or short phrases to assign a label to the data to summarize and provide an inventory of topics for categorizing. Turner (1994) calls this coding method the development of a “basic vocabulary” of data to form “bread and butter” categories for further analytic work (p. 199). An example of a Descriptive code generated was awareness, where six times when reading a qualitative data source sentence, the participants were describing how they were not aware of gender bias until reflecting on real life examples they have experienced while in education. Examples of codes generated from the Descriptive Coding method were underrepresented, barrier, problem solving, and equal opportunities. In total, there were 96 codes created during the Descriptive Coding process that are presented in Figure 4.3.
The next method of coding used in this qualitative data analysis was *Process Coding* that generated 57 codes. During *Process Coding*, gerunds were created as codes to capture an action taking place in the qualitative data. Saldaña (2016) described *Process Coding* as appropriate for all qualitative studies but in particular research that concentrates on “participant action/interaction and consequences” (pg. 66). *Process Coding* was used because the study is exploring the perceptions of participants and their perceptions pertaining to female students in STEM education as an action research study. Research question two specifically asks participants perspectives on the factors that influence females in STEM education. An example of a *Process code* generated was *fearing failure*, where an educator during the semi-structured interview described how female students choose to enroll in less rigorous advanced placement courses that the students know they can succeed in, versus computer science which the students are unsure of what is expected for the computer science course. Examples of codes generated from the *Process Coding* method were *defending themselves, pressuring from peers, working hard*, and *thinking critically*. Figure 4.4 displays an example of *Process Coding* in Delve.

![Figure 4.3 Descriptive Coding in Delve](image)
The third method of first cycle coding used in this qualitative data analysis was *In Vivo Coding* generating 115 codes. *In Vivo Coding* was used in the qualitative data analysis to capture the voice of the educators in this study pertaining to female high school students in STEM education. *In Vivo Coding* draws from the participant’s own language, to display the worldviews, culture and personal experiences of the participants (Saldaña, 2011). During *In Vivo Coding*, a word or short phrase code is generated from the actual language used in the qualitative data. An example of an *In Vivo code* generated was “*socially acceptable*”. In response to a Perceptions of STEM Participant Survey open-ended question, the educator used the words “socially acceptable” when answering about the biggest barriers that female students face participating in a STEM course. The participant explained that the barrier that they perceive is the lack of support and acceptance in STEM fields. Examples of codes generated from the *In Vivo Coding* method were “*girls are different*”, “*conscious persuasion*”, “*interested in STEM*”, and “*who you look like*”. Figure 4.5 displays an example of *In Vivo Coding* in Delve.

![Figure 4.5 In Vivo Coding in Delve](image)

The final method of coding used in this qualitative data analysis was *Value Coding* that produced 67 codes. *Value Coding* was used to identify the participants'
“integrated value, attitude and belief system from their perspectives and worldviews” (Saldaña, 2016, p. 67). Additionally, Value Coding explores the “cultural value, belief systems, identity, intra/interpersonal experiences and action from the participants” (p. 67). An example of a Value code generated was cultural holdover, where an educator during their semi-structured interview described how culture has created a view that girls are bad at math and that idea persists in education today. Examples of codes generated from the Value Coding method were male dominate, gender bias, expectations of females, and soft science. Figure 4.6 displays an example of Value Coding in Delve.

![Figure 4.6 Value Coding in Delve](image)

**Code Mapping**

The first step in Code Mapping was to export the codes generated in Delve to an Excel spreadsheet. The Excel spreadsheet was then transferred to a Google Sheet. The codes were combined into one spreadsheet and alphabetized to merge duplicate codes. Anfara (2008) defines Code Mapping to “bring meaning, structure, and order to data” (p. 932). Through peer-debriefing the codes were analyzed and strategically placed into subcodes using Microsoft Excel. Initially, the corpus of 335 codes was reduced to 242 by the process of merging codes that were synonymous or similar to each other. The similar codes were given a color through conditional formatting to group the similar codes together. For example, the educators in the DASS open-ended responses used a derivative of problem-solving five times. Therefore, these five codes were merged into one code, problem-solving. In continuing the use of Code Mapping, the corpus of 242 codes was
reduced to 91 higher-level concepts codes. Additional iterations of reviewing unduplicated codes resulted in a final corpus of 65 subcodes.

Figure 4.7 Code Mapping from Delve and Google Sheets

**Second Cycle Coding**

*Pattern Coding* was used in the second cycle of coding to condense the subcodes into smaller categories through the discovery of patterns within the first cycle coding codes generated and Code Mapping subcodes (Saldaña, 2016). Reanalyzing the subcodes was completed in the second cycle to condense multiple subcodes into more abstract thinking called categories (Saldaña, 2021). Iterations of processing the 65 subcodes during peer debriefing with my dissertation co-chair produced six categories. The six categories were a) Teachers’ perceptions of female high school student traits, b) Influential factors, c) Challenges in supporting female students within STEM education, d) Underrepresenting women, e) Perceptions of STEM students, and f) Stereotypes of females in STEM.

**Themes and Findings**

The completion of the first cycle and second cycle coding methodologies led to the discovery of three themes for the study. Each code was discussed with my
dissertation chair to create subcategories. The subcategories were then discussed and processed, leading to the development of categories. The themes emerged through peer debriefing that analyzed the participants’ experiences to derive the relevant participants voice from the qualitative data. Butler-Kisber (2018) describes themes as collecting specific wording from data and finding meaning from the researcher’s interpretation of the data resulting in the emergence of relevant themes to describe the data. The three themes that emerged were (1) Teachers perceived the female students' fear of failure to influence why they do not take STEM classes, (2) Teachers perceive cultural influences to impact the choices female students make, and (3) Teachers perceive slight growth away from the traditional school aura that female students are not capable of succeeding in STEM courses.

**Theme 1: Teachers Perceived that Female Students’ Fear of Failure to Influence Why Female Students do not Take STEM Courses.**

The first theme addressed teacher’s perceptions of female high school student traits and the participants’ perceptions of STEM students (see Figure 4.8). Out of the qualitative data sources analyzed in multiple peer debriefing sessions, the creation of subcodes, subcategories, and categories led to the emergence of this theme, teachers perceived that female students’ fear of failure to influence why female students do not take STEM courses. Specifically, the semi-structured interview questions asked individuals their perceptions of factors influencing female high school student’s enrollment in STEM education courses and the factors they felt contributed to the enrollment of female high school students in STEM courses. Bandura’s (1997) Social Cognitive Theory was used to structure the three main factors that participants perceived
as influential: behavioral factors, individual factors, and environmental factors. These factors are similar to the research of Charlesworth and Banaji (2019) who found that students believing in their own abilities affects their future academic choices, especially in female high school students. The two categories that emerged from the dominant subcategories included teacher’s perceptions of female high school students and perceptions of STEM students.

**Figure 4.8. Theme One Development**

**Teachers’ perceptions of female high school student traits.** In this study, participants female high school traits are the perceived characteristics that female STEM students demonstrate. Perceptions of STEM student category in the study are the perceptions of the participants of STEM student traits. Using conditional formatting in Microsoft Excel, once the subcodes within this subcategory were analyzed several important ideas were revealed about the data, for example, confidence. The use of a conditional formatting rule within Excel was created for text that contained “confiden”. This yielded three subcategories: confident, having confidence in themselves, and confidence in ability. This further aligned with the *Descriptive code, confident* which
was generated from the data regarding female students not having confidence in taking STEM courses from the participants' perspectives. For example, Chris stated in the semi-structured interview “and because they’re not completely confident with their ability with the material, they probably just play it safe and stay away from it.” Which when combined with the Process code, having confidence, offered support for the pattern in the data about teachers’ perceptions of female high school student traits.

The category, teachers’ perceptions of female high school student traits, was created out of the subcodes of having confidence in themselves, being successful, fear of failure, changing, positive trend, completely capable, developing more social and cognitive skills, intimidated and standing up for themselves. The two dominant subcategories that led to the development of this category were fear of failure and having confidence in themselves.

**Fear of failure.** The findings of this study found that faculty perceived female high school students' fear of failure in STEM courses to be impacted by gender career biases. The In Vivo code, “don’t want to fail” described the faculty’s perceptions of female students fearing to fail in STEM courses. When combined with Process code, not going to achieve it supported the pattern in the data about faculty perceptions of female students straying away from taking STEM courses because of fearing to fail in these courses (see Figure 4.9). For example, Taylor states “especially girls that are kind of driven have this fear of failure”.

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The subcategory of fear of failure was discovered by comparing the participants' qualitative data responses and combining like subcodes such as *driven by fear of failure, don’t want to fail, not successful, and not going to achieve it*. For example, the semi-structure interview question asked participants what they perceived to be the biggest barrier for female high school student enrollment. Gina stated, “The fear of failure is a barrier.” The connection between being afraid of failure and the impact on gender career bias (e.g., not being shown that they can be successful in other STEM areas) could be seen in two faculty members semi-structured interview responses:

**Chris**  And they are just fearful to try it out. Like I said, fearful of failure.

**Taylor**  But you’ve learned something and pushed and tried something new then it is to take the easy route. So that’s the second part [perceptions] is that a lot of female students that are pushing themselves or do have these high family expectations of good grades, they’re afraid to fail.
Collectively, fear of failure was described by the participants as not excelling or making an above average grade in a course.

Fear of failure could also be seen through the perspective of intimidation as was offered in the research of Kong et al. (2020) who found “discriminatory practices are rooted in larger cultural and social norms, and the definition of gender discrimination is continually evolving” (p. 55). Intimidation in this study was perceived by teachers as a key factor that influenced female students; because of the gender inequality in comparing males and females. Sam referenced this in their semi-structured interview response, “these females are taking the same math classes as these boys so there’s no reason. I think it is a little bit of that bias on guidance, as well. Not that girls can’t be engineers or can’t do things.”

**Having confidence in themselves.** Teachers in this study perceived female students to have less confidence in their abilities to succeed in STEM courses. Furthermore, because the female students do not have confidence in themselves, as well as not wanting to fail, they are not enrolling in STEM courses.
Figure 4.10 Having confidence in themselves subcategory development

Taylor referred to this in their semi-structured interview response, “But I just think unless you are confident in your math skills and that it’s just in your DNA to work hard to not give up. And I guess that’s just not in a lot of the females.” As well, Chris offered in their semi-structured interview response about female student confidence, “So, having confidence. So female confidence in STEM occupations”. Overall, the teachers’ perceptions were that females do not feel like they belong in STEM careers and experience gender disparity in the educational setting as well as within the workforce. Conversely, teachers also shared that an interest and motivation to pursue STEM education can increase STEM enrollment; however, female students who lack confidence are not motivated to enroll in STEM education.

**Teachers’ perceptions of STEM students.** This category reflected how teachers perceived female student to have biased thinking that STEM courses are difficult and are male dominated. Teacher’s perceptions of STEM students were created out of the subcategories of designing, researching, thinking critically, working on computers, hard science, tougher courses, working hard, real world, straying away from hard courses, inquisitive, confident, solving problems and smart kids. This category subsumed a total of 36 codes or 11 subcodes.
Using conditional formatting in Excel as well as multiple peer debriefing sessions, analysis of these subcodes and subcategories revealed several important ideas, including the perceptions of a STEM student as a researcher and STEM courses being tougher. The first of these was that STEM educators perceived a STEM student as a researcher who enrolls in hard sciences and has confidence in their academic capabilities.

For example, Hayden stated “I think young women tend to go more towards what are coded as the soft sciences (see figure 4.12).” Surprisingly, STEM educators Taylor and Chris both stated respectively that “girls tend to go towards hard sciences” clearly “indicates that the stereotypical career for female students is considered soft science”. This aligned with the Process code, researching which combined with the Descriptive code, research supported the pattern in the data about teacher perceptions of STEM students. The two dominant subcategories that led to the development of this category were straying away from hard sciences and tougher courses.
**Straying away from hard courses.** The teachers perceived a STEM student as a researcher who enrolls in hard sciences and has confidence in their academic capabilities.

![Diagram of Straying away from hard courses subcategory development]

Figure 4.12: Straying away from hard courses subcategory development

The participants' perceptions of female students included that they stray away from the hard courses because STEM courses are considered harder. This was found in the participants' comments offered in their semi-structured interviews as well:

- **Jody:** They think it’s too hard.
- **Chris:** And they are just fearful to try it out. Like I said, fear of failure.
- **Hayden:** I think women or young women tend to go more towards what are coded as the soft sciences and are kind of pushed from the, quote, hard sciences.

Furthermore, Taylor stated in her interview that,

- **My best friend actually is on basically a gender bias committee as she was finishing her PhD and she is now a postdoc molecular genetics and...**
she’s also again, still one of the few females in her program. Also, there is still this bias that like when you think of chemists, everyone imagines a male chemistry person.

This comment further supports that teachers in the study see female students taking STEM courses as being too hard and in combination with other influential factors such as STEM courses are tougher+, female high school students tend to stray away from the STEM curriculums. Another pattern that was seen in the data (and led to the development of the subcategory) was tougher courses. For example, the *Descriptive code, tougher courses* described the faculty perceptions of courses female STEM students enroll in. When combined with the *Process code, pursuing more difficult courses* supported the pattern in the data about Perceptions of STEM students.

**Theme 2: Teachers Perceive Cultural Influences to Impact the Choices Female Students Make.**

Theme two was derived from the two categories influential factors and challenges in supporting female students in STEM education (Figure 4.16). Out of the qualitative data sources analyzed resulting in the development of subcodes, subcategory, and categories that led to the development of this theme, the teacher’s perception of cultural influences that impacted female high school students’ choices in taking STEM courses emerged.
The findings of this study revealed that teachers see female high school students being interested in taking diverse types of STEM courses but that there remain gender disparities in the STEM field. Gender disparities as well as women being underrepresented in hard science are examples of how a cultural influence impacts the female students’ choices when considering which STEM courses to take. There is a perception of those in STEM careers to have more masculine characteristics and this then influences the gender role within STEM careers in today’s society.

**Influential Factors.** The category, influential factors, was created out of the subcategory of media influence, early intervention, funding, doubting themselves, promoting women in STEM, encouraging parents, opportunity for female students, perceived roles, recognizing achievement, social media, and friends. Using conditional formatting in Excel, analysis of these codes revealed several important ideas, including perceived roles and encouraging female students. The first of these was perceived roles. For example, roles when referring to gender, were quoted by four separate teachers. Hayden stated, “because of how those different types of fields of science are perceived
or what roles those are what jobs those fields tend to go into.” This aligned with the *In Vivo code, “perceived roles”* which when combined with the *Descriptive code, equal opportunities* supported the pattern in the data about influential factors. Additionally, the *Value code, expectation of females*, identified how faculty in this study still finds certain career choices to be heavily influenced on gender in the STEM areas.

The following two semi-structured interview responses showed that teachers recognized that outside factors could affect the overall choices that female students make when choosing courses or careers.

Jody  And maybe like I said, because there’s so many things to pick from or because there’s so many it’s intimidating to know, hey could I do that job? Because I have so many females, I think that other females are actually intimidated by their own.

Sam  In general, I think that female students are much more likely to go to college than their male counterparts. However, I think that the larger public makes access to STEM jobs harder for women to attain if they are outside of societal norms. As a STEM student and degree holder I was actively shooed away from academic jobs or other STEM jobs because the perception was that I was eventually going to start a family and therefore less worthy of a sport than a male counterpart.

Sam and Jody’s response indicates that social norms have been present in education, even when these teachers were in school. The overall sense from the teachers was the
combined factors of equal opportunities and societal norms can guide students in a specific career path. This contributes to the perception that STEM educators perceive high school female students as being influenced by environmental and individual factors, including bias from the guidance department personnel as well as societal norms.

**Perceived roles.** In this study, teachers perceived female students were influenced by stereotypes that are preinstalled in them at an early age and taught through societal norms.

Figure 4.14 Perceived Roles Development

The participants described perceived roles in the study as predetermined feminine and masculine jobs from society. This aligns with two faculty’s perceptions found in their semi-structured interview responses that female students enroll in medically adapted STEM courses.

Hayden  It might just be because of how those different types of fields of science are perceived or what roles those are what jobs those fields tend to go into. So, life sciences tend to feed into more of a caregiver like a nurse, doctor, that kind of I guess stereotypically feminine
roles, and more women can definitely see those rather than just research or engineering.

Jody  The guidance is automatically putting all the girls in your anatomy classes because they want to be and it’s just that stereotype that girls are nurses.

Contributing to the perceived notion from STEM educators that stereotypes that are placed on specific STEM careers can influence the choice a female student due to the female student not wanting to be placed in the stereotypical masculine course.

**Gender divide.** The importance of culture and societal views as influential factors on female student choices was noted by Charles and Banaji (2019) to be a contributing factor to the gender divide taking place within the STEM field. In this study, the teachers' perceptions acknowledged that the gender divide is more than just grades but also includes biases that are learned at an early age, including that “males are smarter” and “STEM is masculine”. The perceptions of gender divide could be seen from the three faculty members semi-structured interview responses:

Hayden  I think that there might just be a gender divide when it comes to the types of STEM courses. And to solve that, I don’t really know because that was something that I dealt with as a kid.

Jody  I guess the gender stereotype obviously would be that males are smarter. I think there’s definitely a gender bias.

Taylor  You know, especially those [STEM courses] those that are very male dominated.
The responses indicate that the participants perceived that gender divide is present in STEM education and that stereotypes of gender in STEM education are a contributing factor. The participants agreed that specifically at Skyler High School in their classrooms they see an improvement in the gender divide, but the notion of stereotypes still persist in society.

**Challenges in supporting female students within STEM education.** A pattern that was seen in the category data, challenges in supporting female students within STEM education, was gender divide. For example, the Process code, *stereotyping of gender* described the challenges that faculty perceived to be occurring regarding female students within STEM education. When combined with the In Vivo code, “beginning with bias” reinforced the pattern in the data of challenges in supporting female students within STEM education. The category, challenges in supporting female students within STEM education, was created out of the subcategory of cultural, social normality, self-doubting, course selection/bias, equal opportunities, early bias, engagement, gender divide scheduling, recruitment, expectations of females, male dominate, failure is a barrier and engagement. Jordon and Jody both state in their interviews that course selection is encouraged by culture. Taylor states “And I do think it is a little bit of cultural or implicit bias”. Clearly indicating that the STEM educators perceive cultural as a driving factor of influence in high school female students’ career and course choices. Using conditional formatting in Excel, analysis of these codes revealed several important ideas, including cultural influences and gender divide. The first of these was that STEM educators perceived cultural influences as a challenge facing female students when deciding to take STEM courses. This aligned with the In Vivo code, “cultural
“holdover” which when combined with the *Descriptive code, males are smarter* supported the pattern in the data about challenges in supporting female students within STEM education. This category subsumed a total of 67 codes or 14 subcodes.

![Diagram](image)

**Figure 4.15 Challenges in Supporting female students within STEM education**

**Encouraging female students.** Another pattern that was seen in the data was encouraging female students. Encouraging female students was described by participants as influences outside of education that can encourage female students to participate in STEM education, such as family support, friends, and social media. For example, the *Descriptive code, within their families* and *friends* identified who were influential in encouraging female students to enroll in STEM courses. When combined with the *Process code, following social media* supported the pattern in the data regarding influential factors. For example, Hayden stated, “I think media has actually done a better job in education in that area”, when referring to encouraging females. This indicated that STEM educators perceived outside influences as an important factor in encouraging participation in STEM education. This category subsumed a total of 40 codes or 12 subcategory (see Figure 4.16).
Cultural Practices. The findings of this study define cultural practices as beliefs and social norms that a student processes from their culture, either societal culture or family culture. Parker’s semi-structured interview response referenced how certain cultures push their children into specific careers, “I would say no doubt in my CP classes. There’s a whole lot more cultural pressure on students. There’s a lot of retracted expression of interest in STEM.” Hayden’s semi-structured interview response reflected their belief that cultural holdover to be a factor that influences females to continue to follow cultural practices and not go against the values that had been instilled in the female students since birth, “It’s just a weird holdover from older culture”. Cultural influences were also identified in the semi-structured interview response of Jordan: Depends definitely on the culture I see. A lot more Indian girls, for instance, are interested in engineering and things like that. Depending on the culture, certain cultures tend to encourage your children for different careers. It depends on the culture, but the smart kids definitely get pressured more, you know, to become doctors.

Theme 3: Teachers Perceived Slight Growth Away from the Traditional School
Aura that Female Students are not Capable to Succeed in STEM Courses

Theme three was derived from the two categories stereotypes of females in STEM and underrepresenting women (Figure 4.17). Out of the qualitative data sources analyzed resulting in the development of subcodes, subcategories, and categories that led to the development of this theme, the teacher’s perceptions of the factors that influenced female students to not be successful in STEM courses emerged. The findings of the study found that the underrepresentation of women and gender bias have a profound influence on female high school students’ choices. This study found that the faculty participants acknowledged there is a systematic aura that precedes females as being not smart enough or unable to fulfill the hard science requirements. This aligns with the research of Wang and Degol (2017) who found that social roles (also referred to as social norms) are created unconsciously by female students in their choices about STEM courses to take. In this study, the three dominant STEM educators' perceptions regarding female high school student success in STEM courses were gender bias, promoting of women in STEM, and STEM recruitment.
4.17 Theme Three development

**Stereotypes of Females in STEM.** In this study, what the STEM educators perceived regarding gender bias and stereotypical traits of female high school students led to the development of this category. The teachers spoke of how females continue to embody societal stereotypical traits such as being emotional, sensitive, and nurturing. Whereas male STEM students had societal stereotypical traits such as hardworking, strength, and leadership. Additionally, in this study female students were described by educators as being shy and fearful and males were described as confident and researchers. The category, stereotypes of females in STEM, was created out of the subcodes of caring nature, choosing the easier path, fearing failure, quiet, conditioning to take medical courses, soft science, and traditional learning. Using conditional formatting in Excel and multiple sessions of peer debriefing, the analysis of these codes revealed several important ideas. The dominate subcategory was teachers’ perceptions of the female students in STEM have to a caring nature. This category subsumed a total of 29 codes or seven subcodes (see Figure 4.18).

![Figure 4.18 Stereotypes of females in STEM category development](image)
Female Student Traits. The pattern found within the codes was that female students in STEM courses are more caring in nature. This developed out of the In Vivo code, “personality trait” which combined with the Value code, social developed, supported the pattern in the data about faculty’s perceptions of stereotypes of females in STEM.

In this study the participants described female student traits as caring nature and soft sciences as stereotypes that are placed by society on female students. The participants described female students at Skyler high school as having confidence and that STEM education is changing for female students in a positive trend. Chris stated in their interview that “I don’t notice females being shying away from the STEM courses from a science perspective.” Hayden stated in their interview “I think that’s largely been positive” and doctor jobs are more caring positions, rather than something like physics or engineering.” These statements clearly indicate that a positive trend is present when referring to females in STEM education but that stereotypical traits placed on females in society still causes female students to be pushed into soft sciences that are considered more nurturing.

Gender bias. In this study, there was an unconscious gender bias of the participants towards STEM education courses and enrollment by female students at Skyler High School. The teachers’ qualitative data responses offered a diverse representation about the Skyler High School STEM education curriculum but also identified that in the real-world females are underrepresented in STEM careers, other than in medical fields such as nursing. As shared by Jordan in their semi-structured interview response, “I do see things are changing and getting better. I’m seeing more
girls that are interested in STEM". As well, in Taylor’s semi-structured interview response:

She likes to do things with their hands, and I know a lot of it’s starting to change a little bit, especially with some of our RDA classes, but I think that some of it, and then I also think it’s the idea that a lot girls still perceived that they should kind of be quiet in class.

As seen in the semi-structured interview response by Chris, “That is because the ones [female students] that take it [STEM courses] are brilliant. You know, they are completely capable”. Along with the research findings of Williams and Williams (2010) the study found that female students’ attitudes can be created by the community and environment, affecting their perceptions in STEM education, including self-beliefs and performance.

Figure 4.19 Gender Bias subcategory development

The qualitative findings of this study found that teachers’ perceptions about gender bias can be unconscious yet still influence class selection of high school females.
This is consistent with the research of Kong et al. (2020) who found gender bias is rooted in discriminatory practices and social norms contributing to low participation in STEM for females. Discriminatory practices and social norms were discussed in the semi-structured interviews of two participants. Jody and Hayden do not see a curriculum bias in their specific classrooms but acknowledge that stereotypes are still present today in specific STEM careers.

   Jody  I don’t think it’s worded in a way to encourage or discourage kids to take the actual class, but I do think once they’re in it, I think there’s definitely a gender bias. I think there's definitely a gender bias. It’s just a stereotype that girls are nurses.

   Hayden Oh, girls are just bad at math. That is, it’s a second level of Project Lead the Way which is nurse coded. I only have 14 students and only three are boys.

The data that supported the findings included the pattern that found in the category data, underrepresenting women, was gender bias. For example, the Value code, normality which described the under representation of gender in STEM careers when combined with the In Vivo code, “too much gender bias” supported the pattern in the data of underrepresenting women. The findings show that the gender bias that is still present, even if not at Skyler High School, which creates the underrepresentation of women in STEM.

Underrepresenting Women. The category, underrepresenting women, was created out of the subcategory of modeling in society, STEM recruitment, increasing female participation in STEM, diversity, and inclusion. Using conditional formatting in Excel,
analysis of these codes revealed several important ideas, including role models and
gender bias. Chris, in her semi-structured interview, expressed the difficulty of pursing
an engineering career because there was not a female role model and stated, “if a guy
can do it, I can do it”. The first of these was that STEM educators perceived the factor -
underrepresenting women - to include role modeling in society and gender bias. This
aligned with the In Vivo code, “wasn’t a role model” which when combined with the
Process code, increasing female participation in STEM supported the pattern in the data
about underrepresenting women. This category subsumed a total of 23 subcodes or six
subcategories.

Figure 4.20 Underrepresented Women subcategory development

Promoting women in STEM. The research found that factors can have an impact
on students. The participants of the study expressed concern that STEM education has to
start at an early age and be seen by female students. The qualitative data findings of this
study found that teachers perceive an early intervention in recruiting and promoting
women in STEM to influence female high school students. The three participants Sam,
Chris and Parker gave the suggestion that students need to see STEM education at all
levels through promoting STEM education for all students.
Sam: I feel like promoting STEM at the middle school levels for all students and I think that would help.

Chris: We need to promote that within ourselves. You now, you see that, and a student and you say, hey have you ever considered for example, engineering.

Parker: And it’s similar to this, that promotion [physics course], all promotions, use male characters and that’s just promoting a class and the images are not the person anything just an image to connect to whatever is being said about physics or promoting it.

The promotion of STEM education can lead to an increase in STEM recruitment. The findings of the study show participants perceive STEM recruitment as an influential factor in increasing female students in STEM education and courses.

*STEM recruitment.* STEM recruitment falls under Bandura’s (1997) Social Cognitive Theory and past research of educational factors. The qualitative data findings of this study found that recruitment for females in STEM education to be present at Skylar High School. However, that recruitment needed to be implemented at an early age to influence female high school students' decisions in taking STEM courses. This notion aligns with the research of Hand et al. (2017) who reported teachers associated STEM professionals as being masculine and concluded that not many female STEM role models are available for female students. Therefore, the lack of female inclusion and visibility of STEM role models can influence female students' involvement in STEM courses and STEM careers. This concept was found the semi-structured interview responses of three participants as well:
Chris: I get a lot of mailings and a lot of emails about inclusion in recruiting females. Right now for females in that area [computer science].

Jody: So therefore, my answer to that is there’s a lack of recruitment. There’s not a lot of recruitment and it’s all at home and it’s not happening at home.

Sam: Maybe having students begin planning out what they could see themselves doing given them options at the earliest possible.

**Draw A STEM Student Instrument**

The DASS Instrument (see Appendix E) was adapted from the Draw a Scientist Instrument (Mead & Métraux, 1957), and included six standardized predetermined indicators to identify when analyzing the participants’ artifacts: (1) appearance, (2) symbols of research/scientific instruments (3) symbols of knowledge, (4) technology products, (5) dimensions of diversity, and (6) environment. It should be noted that six research participants did not complete this instrument. Additionally, five participants provided a picture or open resource image instead of themselves completing a drawing. Five of the eight participants who manually drew their response to the direction of “Close your eyes and imagine a STEM student at work and in the space below draw what you imagined”, drew a stick person. There was only one hand drawn artifact that offered content in their drawing beyond rudimentary features.

This author and one of the dissertation chairpersons reviewed the 13 drawings from participants independently to validate the frequency counts offered in Table 4.4. Determining the frequency of something occurring as a quantitative analysis summarizes the categorical data and clearly presents the counts for all variables (Wetcher-Hendricks, 2011). A frequency chart (see Appendix G) was used by both the researcher of this study
as well as one of their chairpersons to determine how often a participant included in their drawing one or more of the standardized indicators. There was 97% accuracy between this researcher and the second reviewer (one of my dissertation chairs) in the identification of an indicator being found in a drawing offered by the participant upon independent review.

Table 4.4 Frequency of the Six Indicators of DASS Artifacts by Participants (N=13)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>8</td>
</tr>
<tr>
<td>Symbols of Research/Scientific Instruments</td>
<td>14</td>
</tr>
<tr>
<td>Symbols of Knowledge</td>
<td>8</td>
</tr>
<tr>
<td>Technology Products</td>
<td>10</td>
</tr>
<tr>
<td>Dimensions of Diversity</td>
<td>18</td>
</tr>
<tr>
<td>Environment</td>
<td>10</td>
</tr>
</tbody>
</table>

Of the six standardized indicators, the 13 participants most frequently included in their drawing a dimension of diversity (frequency of 18). Frequency is an appropriate measure for qualitative data because it allows a snapshot of the information and displays the frequency of the indicators from the data (Saldaña, 2016). A dimension of diversity meaning gender, ethnicity, or age found in the drawings provided by the participants. Gender was the only aspect of this indicator found in the participants’ artifacts. There were four times when the gender was clear in the artifact provided by the participant (two times a female, two times a male). As noted, many of the drawings were of a stick person and elementary in their development so an obvious gender could not fairly be indicated.
about the artifact. For the indicator of appearance, where examples of wearing a lab coat, having facial hair, or wearing eyeglasses were looked for within the drawings provided by the participants, there was six times when the artifact included a person to be wearing some form of eye wear or protective eye covering (i.e., googles). For the indicator symbols of research/scientific instruments, there were eight times when the participant included in their artifact some form of scientific instrument such as a Bunsen burner, beaker, or funnel, and six times when a suggestion of computer programming was present. For the indicator of symbols of knowledge, there were four times when the participant included in their artifact some form of a book and two times when the participant included some equation representation in their drawing. For the indicator of technology products there were 11 times when the participant included in their artifact some form of a tablet, laptop, computer, or keyboard. For the final indicator, environment, there were nine times when the participant included in their artifact some form of a classroom or a scientific laboratory. Figure 4.21 offers an example of a participant’s artifact where there was 100% agreement between the researcher and the second reviewer that the drawing included the indicator of symbols of research/scientific instruments (i.e., a Bunsen burner), the indicator of symbols of technology (i.e., a laptop), and the indicator of appearance (i.e. eyeglasses).
Chapter Summary

As this was a mixed-methods action research study, both quantitative and qualitative data were collected and analyzed. Quantitative data was collected using Perceptions of STEM Participation Survey, Sex Typing Occupation Survey, and DASS Instrument. The key takeaway findings from the quantitative data analysis were that certain careers are still considered more masculine and feminine, high school STEM educators were between a slight disagreement to being neutral about the statements presented concerning female high school students’ participation in STEM courses, and STEM students are associated most with the characteristics of dedicated and intelligent.

Qualitative data was collected using one open-ended question from the Perceptions of STEM Participant Survey, two open-ended questions from the DASS Instrument, and semi-structured interviews. Three themes emerged from the qualitative data: (1) Teachers perceived the female students fear of failure to influence why they take STEM classes, (2) Teachers perceive cultural influences to impact the choices female
students make, and (3) Teachers perceive slight growth away from the traditional school aura that female students are not capable to succeed in STEM course.
CHAPTER 5
DISCUSSION, IMPLICATIONS, AND LIMITATIONS

This chapter positions the findings with the literature on gender bias in STEM education pertaining to high school female students’ participation in STEM education. The purpose of this descriptive research study was to describe Skyler High School STEM education teachers' perceptions of gender bias and factors contributing to low female enrollment in STEM courses to answer the two research questions driving the study: (1) what are high school STEM educators’ perceptions regarding gender bias in the STEM School of Study cluster at Skyler High School? and (2) what factors do STEM educators perceive as contributing to low participation among female high school students within the STEM School of Study cluster at Skyler High School, to advise teachers and other stakeholders on gender bias in STEM education. Based on the findings of this study, recommendations for increasing female high school female students in STEM education including early interventions, professional development, and community involvement will be discussed in the recommendation section of the chapter. This chapter is organized into the following sections: (a) discussion, (b) recommendations, (c) implications, and (d) limitations.

Discussion

In the Discussion writing, the findings of this study are interpreted and described in comparison to what past research has already determined about gender bias in STEM education (Mertler, 2017). Quantitative and qualitative methods were utilized from data
collection and analysis in this study to answer the research questions, including supporting evidence from previous research studies pertaining to gender bias in STEM education. To specifically answer the research questions, the data was combined and considered through a lens of conceptual understanding of gender bias pertaining to high school female students and the research-based literature. The theoretical framework of the study refers to Bandura’s Social Cognitive Theory that explains how environmental, behavioral, and personal factors can influence individuals' choices (Bandura, 1997; Oppong, 2014). In addition to Social Cognitive Theory, Wang and Degol (2017) determined in their study that along with the three factors of Social Cognitive Theory, biological and social culture are extended factors that describe the underrepresentation of females in STEM education. The discussion of the findings is divided into two sections: (1) RQ1- What are high school STEM educators' perceptions regarding gender bias in the STEM School of Study cluster at Skyler High School? and (2) RQ2- What factors do high school STEM educators perceive as contributing to low participation among female high school students within the STEM School of Study cluster at Skyler high school?

**RQ1- What are high school STEM educators’ perceptions regarding gender bias in the STEM School of Study cluster at Skyler High School?**

The fundamental aspiration for this research question was to discover if STEM educators at Skyler High School perceived a relationship between gender bias and low female participation in STEM courses. To support this point, past literature has drawn educators’ perceptions of gender bias through the use of surveys and semi-structured interviews, which are triangulated to provide a snapshot of participants’ perceptions from the analyzed data of their studies (Charlesworth & Banji, 2019; Londot, 2018; Medina-Jerez
et al., 2010; Pantic et al., 2018; Wang & Degol, 2017). Collectively these researchers identified an underrepresentation of females in STEM education formed by societal views of gender that causes a disparity in female representation. Furthermore, the studies determined that individual beliefs can be influenced by implicit and explicit bias from individual beliefs and behaviors, as well as organizational culture and practices that shape individual perceptions (Charlesworth & Banaji, 2019; Hand et al., 2017). These findings along with the findings of this research study found that gender bias can be found in the educational push for female students to enroll in humanitarian courses and careers. Along with the masculine and feminine categorization of careers from society, biological influences can determine the attitudes that female high school students have towards STEM education. What follows reveals (a) gender bias, (b) biological influences, (c) social norms, (d) stereotypes of STEM students, and (e) underrepresentation of female students and how each influences female high school students taking STEM courses.

**Gender Bias**

The findings of the study found STEM educators in this study perceived a push from guidance counselors and society to enroll female high school students in humanitarian courses, such as nursing. The push for female students to enroll in humanitarian courses is perceived by educators of this study to be tied to societal norms that are placed on STEM careers as either masculine or feminine. The educators of this study identified how societal norms placed STEM careers as either masculine or feminine. This was found in the interview response of an Anatomy and Physiology teacher, Jody. Jody identified in their semi-structured interview response that guidance counselors are automatically “putting all the female students in the anatomy classes due
to society's stereotype that girls are nurses”. An explanation for the push of guidance counselors in humanitarian courses that could be brought on by gender roles that are assigned to males and females from a young age that creates the unconscious bias that influences their guidance/interaction for course placements. This finding aligns with the research of Wang and Degol (2017) who found in their study that female high school students’ behavioral influences can be influenced by unconscious bias is placed on female students to be placed in humanitarian roles. Jody’s response further demonstrates their perception of gender bias in STEM education to not implicitly encourage or discourage students from taking a specific STEM course but once students are enrolled in a specific STEM course gender bias is present.

The quantitative findings of this study showed as well that the teachers at Skyler Highs school perceived certain careers as more feminine or masculine (e.g., female careers being a registered nurse, certified nursing assistant, or dental hygienist, and male careers being waste management, air traffic controller or orthodontist) and that female students are more successful in interactive science fields, such as behavioral or medical fields. While there were two participants who were under the age of 25 the majority were 31-50 years of age representing a generation where people entered fields that were gender specific to views of the society. These findings align with Hand et al.’s (2010) research study which found similar outcomes showing the societal views of males being seen in more STEM related careers like a land surveyor or instructional technology position. These views from society create gender bias that is placed on certain STEM careers where female students do not want to be seen as masculine causing a decrease in enrollment in STEM education (Mulvey et al., 2010).
The findings of this study revealed that teacher perceptions about gender bias and occupation paths are not different from societal perceptions. Hayden described in their semi-structured interview how perceived roles from society are an “influence as to why females tend to go more into life sciences like caregiver or nurse because they are stereotypically feminine roles”. STEM educators voiced their perceptions on perceived roles that are assigned to females by society including nursing and caregiver careers.

**Biological Influences**

The findings of the study supported that teachers still find certain career choices to weigh heavily on one's gender in STEM areas. Biological influences refer to the time when a student forms his or her identity and that includes career choice (Erikson, 1994). Additionally, gender development starts at an early age through childhood experiences that influence female students in decision-making skills. The research of Hand et al. (2010) found that teachers perceived males as more rational and females to be more emotional in their behavioral traits. The finding of this research study along with the past research of Wang and Degol (2017) demonstrate that a biological connection can be made to the influence of career choices and female perceptions through individuals’ personal values, goals, social identities, competence to succeed, cognitive ability, and motivation. Past research has also found that even with women having more balanced math and verbal abilities than men, females continue to choose careers based on interest and values in non-STEM fields (Valla & Ceci, 2014). Converged data from the quantitative and qualitative findings of this study showed that participants disagreed that there are significant biological and/or cultural barriers to successfully completing a high school level STEM program for female students specifically at Skyler High School.
Social Norms

Similar to the findings of this study, Varma’s (2010) research found gender bias can be correlated to how society teaches children assigned cultural roles. The research by Charles and Banaji (2019) discovered that teachers’ perceptions about gender divide goes beyond grades, and how the biases are learned at an early age, where stereotypes like males are smarter and STEM is masculine are introduced. The research by Kong et al. (2020) summarized their findings to show that the discriminatory practices are rooted in larger cultural and social norms, which were similar findings to the perceptions of STEM educators in this study. Hayden’s response demonstrates the perception that stereotypes are present in society, “female students need to be protected from the notion that math is hard, and girls are bad at math”. An explanation of these findings is that family and culture still have a hold of society and the decisions students make due to gender bias. Suggesting that it is just a “weird cultural holdover” from an older culture that still influences the gender bias notion today. Past research by Carrell (2001) and Hand et al. (2017) found that female student decision-making when choosing non-STEM fields are impacted by individual choice from stereotypical social norms that are seen in society. Contributing to the perceptions that STEM educators indicated that culture is a factor when referring to influencing high school females in STEM courses.

Society does hold a huge factor in how females see STEM education but teachers from this study felt like that is changing. When converging the quantitative and qualitative data outcomes of this study, Skyler High school teachers agreed there are social norms that create a larger cultural holdover when referring to STEM careers and education. Aligning with the past research results from Kong et al. (2020) and Sax et al.
(2017) that showed discriminatory practices are rooted through social norms that affect the gender bias in STEM education in relation to the Social Domain Theory. The Social Domain Theory identifies children starting at an early age categorizing groups for inclusion or exclusion based on social norms.

**Stereotypes of STEM Students**

Stereotypical perceptions of a STEM student include rational, hardworking, strength, and leadership (Moss-Racusin et al, 2015). The combined findings of past research align with the findings of this research, that teachers have a stereotypical view of STEM students and STEM careers. The quantitative data of this study showed faculty participants perceive STEM students as intelligent, dedicated, math and science students, who are kinesthetic learners and creative problem solvers. The finding of this study revealed that educators perceived STEM students as smart students taking hard science courses, working on computers and thinking critically. As well, the educators perceived the STEM students as inquisitive and taking tougher courses. Both Hayden and Taylor offered responses in their semi-structured interviews supporting the perception that female students' attitudes towards STEM education is due to gender stereotypes such as “males are smarter” and “STEM is a very male dominated field”. It is these stereotypes perceptions, therefore, which pushes the female high school students to go more towards what are coded as soft sciences versus the hard science courses.

Society places a stereotypical bias of STEM characteristics as having a masculine appearance and masculine social status, which discourages female students from enrolling in STEM education. The combined quantitative and qualitative data of this study regarding the stereotypes of STEM students showed Skyler High School teachers perceived STEM students to be wearing lab coats and eyeglasses, having facial hair, and...
conducting experiments in a classroom or laboratory environment. This aligns with the research by Thomoson et al. (2019) who discovered that the stereotypical view of STEM students included lab coats, eyeglasses and facial hair. Parker described in their semi-structured interview response of this study that “all the promotions for a physics course offered at the high school only used male characters” connecting that image to physics as being male dominated. This correlates with past research from Hand et al. (2017) who also found among STEM professionals, that there is a perception of those in STEM careers to have more masculine characteristics and this then influences the gender role within STEM careers in today’s society.

The finding of the study specific to female STEM students, the educators’ perceptions of female STEM students in this study were the opposite of the stereotypical perception of a STEM student found in the existing research (Kong et al., 2020; MossRacusin et al., 2015; Valla & Ceci, 2014). Stereotypical perceptions of female STEM students include traits like emotional, sensitive and nurturing. Teachers of this study perceived female STEM students as having a caring and quiet demeanor, choosing easier academic paths, and fearing failure.

Underrepresentation of Female Students

The phenomenon of social norms that prevent females from pursuing masculine careers (careers that are deemed strong and leadership positions held by men) creates an underrepresentation of females in strong STEM occupations (Charlesworth & Banaji, 2019). Therefore, this decreases female high school enrollment in STEM education. STEM educators in this study agreed strongly that female STEM students benefit from a female mentor. Ellison and Vitak (2015) discovered in their study that social influences, such as female role models, can create unknown biases or decisions about the educational
choices of high school female students. Past research that investigated student choice found a significant correlation between social norms placed on STEM professions or courses and the influence the perceptions play on STEM pathway selections from female students (Adelsberger, 2020; Sahin et al., 2013). The findings of the study indicated that STEM educators do not see a significant gender bias in STEM education at Skyler High School but identify a continued overall gender bias by societal norms that is seen through the underrepresentation of women in STEM careers.

**RQ2- What factors do high school STEM educators perceive as contributing to low participation among female high school students within the STEM School of Study cluster at Skyler High School?**

This research question aimed to explore the key factors the STEM educators perceive to contribute to low female high school participation in STEM courses at Skyler High School. To support the factors identified below in this study, the outcomes of Charlesworth and Banaji (2019), Domenech-Botoret et al. (2017), Pantic et al. (2018), Varma (2010), Williams and Williams (2010), and Wigfield and Eccles (2020) were considered. These researchers found the self-efficacy, parental influence, environmental influences, and educational organizational influences are the key factors contributing to female high school students’ low participation in STEM courses. Both quantitative and qualitative data sources of this study were converged to report the Skyler High School STEM educators’ perceptions about key factors. The instrumental factors the STEM educators of this study perceived to contribute to low participation among female high school students in STEM courses align with Bandura’s Social Cognitive Theory (1997) categories of (a) behavioral factors, (b) environmental factors, and (c) individual factors.
Behavioral Factors

Behavioral factors can be learned through observation learning including imitation and modeling (Correll, 2001). Bandura’s Social Cognitive Theory (1997) supports that students learn from imitation and modeling. When looking at converged data outcomes of this study, specific to female high school students’ behavioral influences from the educator’s perspective, unconscious bias is placed on female students to be placed in humanitarian roles. Past research by Hand et al. (2017) found both teachers and students perceived humanitarian roles and behaviors as a female student trait. Wang and Degol (2017) found in their study that conscious or unconscious bias, either by teacher or student, creates gender inequality in the academic environment. The perception of the educators of this study is that female students are pushed towards nursing or soft sciences courses. Four STEM educators shared their perception in their semi-structured interviews that guidance counselors need to “check their own bias” and need to “not automatically put girls into soft sciences because that is the stereotype that girls are nurses”. Sam, a female Science instructor, shared a personal experience with gender bias, “I was actively shooed away from academic jobs or other STEM jobs because the perception was that I was eventually going to start a family and therefore less worthy of a spot than a male counterpart”. The personal quote from Sam supports the findings from this study and past research from Charlesworth and Banaji (2019) that females do face challenges when pursuing STEM education and careers.

STEM educators in this study identified how female students’ personal life choices could prevent their successful enrollment in high school STEM courses. It is also noteworthy to share that STEM educators perceived female students at Skyler High
School to be fully capable of successfully completing STEM courses. Still, the STEM educators described the female STEM students as shy and thinking STEM courses are too difficult. The study by Charlesworth and Banaji (2019) as well as the findings of this study found that educators believe that women need to be incorporated more in STEM educational courses and STEM careers.

**Environmental Factors**

Environmental factors happen outside of a person and can include family, friends, peers at work, classmates, and educational curricula (Meagher, 2020). One factor seen in the quantitative outcomes of this study was educational opportunities because of the parents’ ability to provide supplemental education or continuing education for their child. A student’s access to technology also influences how females’ behavior and attitudes relate to a STEM education. STEM education enrollment can be influenced by parental and environmental factors that are placed on female students, either in the classroom or at home. Past research has determined that parental educational attainment is the strongest predictive factor in the college selection process (Cabrera & La Nassa, 2001). STEM educators in this study, from the converged data, found that female and male students received the same parental support at home but agreed that cultural/parental influence can affect the choices a student makes in their course selection. Panquart and Ebeling (2020) found in their study that parental influence and parental values influence the expectations of education for their children.

STEM educators in this study did not perceive a significant academic bias in the STEM curriculum at Skyler High School. The converged data showed that the STEM educators do not see gender bias in the STEM curriculum that they are personally
teaching in their classrooms. Tyler, a math teacher, stated in their semi-structured interview that they see an equal balance of male and female students in their class attendance as well as their success rates in their class. The influence on educational choice and future aspirations in a high school’s curricula in science and math, and the gender segregation of extracurricular activities “have large effects on the gender gap in plans to study STEM fields, and these effects are robust to the subfields we use to define a STEM orientation” (Legewie & DiPrete, 2014, p.16).

**Individual Factors**

The findings of the study found that female students are afraid of failure and are not shown they can be successful in STEM areas. The findings show that Skylar High School teachers perceived female students to assume STEM areas are too hard. In combination with other influential factors, female students tend to stray away from the STEM curriculums that are perceived as masculine from society. Jody, an honors Math instructor, stated in their semi-structured interview “She doesn’t think she’s top notch therefore she wouldn't take an AP course”. An explanation of why female high school students does not consider taking AP courses can relate to their fear of failure and low self-efficacy driven from societal views. The findings align with Kong et al. (2020) and Affuso and Miranda (2010) that both individual’s belief and attitudes toward STEM derived from societal views can influence a female students’ attitude toward STEM education. Additionally, they found in their studies that a student must have intrinsic motivation (from within themselves) and learn from their own enjoyment to succeed in a course or task. Therefore, as Nugent et al. (2015) discovered in their study, the importance of predicting career inspirations significantly relates to basic interest in
decisions to pursue STEM higher education. The individual factors of self-efficacy, self-determination, and fear of failure are discussed further.

**Self-efficacy.** The finding of this study revealed that teachers perceive female students to be afraid of failure and are not shown they can be successful in other STEM areas. The findings indicated that teachers perceive female high school students assuming other STEM areas as too hard and combined with other influential factors, female high school students tend to stray away from STEM curricula. Chris shared in his semi-structured interview the perception that “female STEM students' lack confidence, and their fear of failure can be linked to STEM occupations and not having exposure to confident female STEM individuals”. An explanation for these findings for lack of confident can from the underrepresentation of female STEM leaders in the community or in the female students’ everyday lives that unconsciously create doubt for future STEM courses exploration. These findings align with the research of Domenech-Botoret et al. (2017) who concluded in their study that future academic choices can be predicted when individuals believe in their own abilities. As well, an individual's belief in their own capacity to achieve in contrast to attitudes toward STEM can be influenced by outside factors. An open-ended response that was given in the Perception Survey described barriers as “the biggest barrier for female students is self-worth and that they do not know their own worth”. The findings of the study align with Yoo & Smetana (2022) which found that a direct correlation can be found between intrinsic motivation in educational courses and motivation to pursue specific courses extensively. Therefore, STEM courses must be attainable and relate to the future of the female students, along with the student’s finding enjoyment in the STEM course for them to continue pursuing a STEM education.
**Self-determination.** The findings of the study found that self-determination is perceived as a barrier from the participants for high school female students in pursuing STEM courses. Sam reinforced this point in their semi-structured interview response, “I feel like promoting STEM at the middle school levels for all students and I think that would help”. Chris, a Computer Science instructor, stated that in their semi-structured interview response, “STEM educators must promote within ourselves to show students visibility in STEM education”. An explanation of these findings can include STEM education not being visible in early education through promotion and exposure to STEM education in a positive way in early education. The findings of this study align with researchers Hand et al. (2017) and Xie et al. (2015) whose research findings found that self-determination must be paired with support from educators by providing STEM course experiences related to the students' own interest and enjoyment. Self-determination as an intrinsic source of motivation comes from within a student based on their own interest and values (Deci & Ryan, 2000). Self-determination in past research was paired with extrinsic motivation where the combination of both elements can increase the participation from female students in STEM education (Correll, 2001).

**Fear of failure.** The findings of the study indicate that participants perceived fear of failure to be a major factor that contributes to low participation from high school female students in STEM education. Two educators offered responses in their semi structured interviews specific to students' confidence in their ability to succeed in tougher STEM courses resulting in them having a fear of failure. Taylor and Parker perceived that girls do not participate in harder STEM courses because “they do not want to get a bad grade” and “fear failure”. An explanation of these findings can be related to Bandura’s
Social Cognitive Theory where students’ performance is significant to the outcomes of task choice. This aligns with Williams and Williams (2010) study that found that the importance of accomplishing the task successfully can affect student performance and task choice. The participants of this study saw the female students being unsure of themselves in STEM education because of outside factors but agreed that they are seeing a positive change in female participation in STEM education at Skyler High School.

**Recommendations**

The recommendations from this study are directed towards educators, administration, STEM professionals, and educational organizations. The recommendations are provided to guide the stakeholders on recommendations to increase female student enrollment in STEM education from the research outcomes of this study as well as past research studies. The recommendation section will discuss three recommendations (1) early intervention, (2) professional development, and (3) involving community.

**Early Intervention**

It is recommended that school districts implement a diverse STEM education program that starts in early childhood education. Tsan et al. (2016) found that adolescents internalized societal representations to understand who they can be and what they can achieve. Creating a positive learning environment and exposure to STEM education at an early age can increase a students’ confidence in taking STEM courses which could affect female high school students' enrollment positively (Grossman & Porche, 2014). Both studies support that early exposure to STEM courses can increase positive attitudes towards STEM education (Grossman & Porche, 2014; Tsan et al., 2016). Sam stated in
their semi-structured interview that “students should start planning as early as possible so those students can see themselves in taking STEM courses”. The converged data revealed that participants believe that gender bias can show as early as third grade and that providing early intervention programs in STEM can provide female students with more choices and confidence in enrolling in STEM education. The Social Domain Theory states that childhood experiences influence decision-making skills (Mulvey et al., 2010). This theory underpins the idea that all programs must be inclusive, and all students should be encouraged to participate in any program offered. Past research also recommends implementing STEM programs that will be used throughout the students’ learning, starting in elementary school (Tsan et al., 2016). Additionally, female representation in STEM fields should extend into core classes and extend beyond what is seen in English and Math. STEM educators of this study agreed that early interventions in middle school, like providing additional STEM programs, would benefit the enrollment in STEM courses for females at the high school level.

**Professional Development**

It is recommended that school districts require diversity training for all teachers and support continued educational pursuits to ensure STEM educators have the proper tools and practices to teach STEM education to all students. Along with the Social Domain Theory, students start to categorize groups based on stereotypical societal views. Researchers also suggest creating student choice to influence female student decision making in participating in STEM education (Hand et al., 2017). Professional development and diversity training will not only provide key 21st century skills needed for the classroom but will also allow self-reflection for teachers to create confidence in
STEM education at the district level. Legewie and DiPrete (2014) found in their study that training teachers in gender diversity and providing extracurricular activities for students have a large effect on the gender gap in STEM education.

**Involving Community**

A final recommendation is for elementary, middle, and high schools to participate in planned STEM nights for the community. Creating community-level involvement can encourage students and parents to consider STEM education as an option for all students. Past research by Wojnowski and Pea (2013) found two key examples from their data including after-school programs in STEM and a Museum of Science to create a collaborative organization where STEM opportunities become more visible in the community. Researchers Dawes, Long, Whiteford, and Richardson (2015) found that both formal and informal activities and experiences, including extracurricular activities in the community, can positively influence a student’s future choice in STEM. Providing community representation does not only afford students with STEM role models but creates opportunities for lifelong learning in STEM education by providing public awareness to families and communities about the importance of STEM.

**Implications**

This research has implications for me, for practitioners, as well as for scholarly practitioners and researchers. Four types of implications are considered: (a) personal implications, (b) implications for teaching practices of STEM courses, and (c) implications for future research.
Personal Implications

As a result of this study, my worldview on gender bias in STEM education has expanded not only as a researcher but as an educator. The reflection of the semi-structured interviews and surveys created personal interventions that I will be introducing into my own pedagogy. The pedagogical strategies I will introduce into my teaching include supporting student exploration in STEM courses by providing representation of females in STEM education and by providing publications and real-life examples of successful women in STEM.

An unexpected outcome of these findings was the importance of self-efficacy pertaining to female students from the perspective of the STEM educators at Skyler High School. Varma (2010) found that female students did not feel like they belonged in the STEM careers due to gender disparity in educational organizations. A female student's doubt or confidence in their abilities to complete material successfully can create an unconscious bias that when paired with personal beliefs can cause a barrier for some females in STEM education (Smeding, 2012; Wang & Degol, 2017). This perception of self-efficacy as a barrier is also seen in the research of Williams and Williams (2020) who found that students in 22 nations who felt like they belonged in the class performed significantly higher. Through a time of self-reflection on these self-efficacy findings, I will be more intentional in my current teaching practices and representation of materials that are utilized in my classroom. I will use a new lens to review each lesson implemented in my classroom to ensure that gender bias is not consciously or unconsciously presented in the material.
I was also pleased, as well as surprised, at the number of personal experiences regarding gender bias that this study’s participants shared in their semi-structured interview responses. It was interesting to learn how many of their own personal experiences shared took place in their early childhood education. This further supports my own desires to encourage exposure to STEM education at all academic levels in the district and in becoming an advocate for females in STEM education by creating afterschool clubs to represent females in STEM educations.

**Implications for Teaching Practices of STEM Courses**

Teaching practices in STEM courses should include diversity training to check the educators unconscious bias that could be represented in the classroom. Teachers should implement choice and provide STEM awareness for all students, including gender bias (Hand et al., 2017). An unexpected finding from this study was that STEM educators at Skyler High School perceived that gender bias is not an issue in their own classrooms. Surprisingly, when educators were asked about their perceptions referring to female enrollment in behavioral or medical courses, teachers still voiced their perception that even with increased female presence in the specific courses, the educators view a positive change in female participation in STEM education in the future. The participants did, however, acknowledge that gender biases continue to be evident by their perceiving behavioral or medical occupations as being more feminine oriented occupations.

**Implications for Future Research**

The study found that female student choice of STEM enrollment is influenced by behavioral, environmental and individual factors. The prominent factors that were
discovered in this research as well as found in past research studies included self-efficacy, self-determination, educational material, modeling, and societal norms (Charlesworth & Banaji, 2019; Hand et al., 2017; Wang & Degol, 2017; Williams & Williams, 2010). Both past researchers and this researcher suggest future research would benefit greatly by expanding the interview participants to include student voice and their perceptions regarding female enrollment in STEM education. Additionally, to include students not only at the high school level but the perceptions from students at the elementary school level. Future research should concentrate on the key factors of gender bias (e.g., self-efficacy, recruitment, and underrepresentation) to avoid an oversimplified gender bias perception about their population being studied. To further support the existing research on the underlying factors of choice (Sahin et al., 2013) and self-determination (Williams & Williams. 2010) and how these key factors impact female students enrolling into STEM education at the high school level is encouraged.

**Limitations**

As with any research study, there are limitations that should be noted. The limitations of this study include small sample size, the inability to generalize action research outcomes, researcher bias, and lack of diversity among participants. The limitations are discussed in the following two sections (1) methodological limitations and (2) limitations associated with findings.

**Methodological Limitations**

Data was collected from only one high school of STEM educators resulting in a small sample size of 20 participants. Of these 20 people, seven semi-structured interviews were conducted. By selecting only STEM educators at Skyler High School through
purposeful sampling, those who meet the criteria of teaching STEM courses may have not addressed other professionals who also play crucial roles in the process (Palinkas et al., 2015). Therefore, the small sample size of this study is a limitation because the study may not represent all of STEM educators’ perceptions in the district and beyond (Faber & Fonseca, 2014).

Action research is not generalizable and focuses on systematic inquiry into one’s own practice (Mertler, 2017). Action research focuses on self-reflective inquiry that can be utilized by teachers specific to their own practices and experiences and the action research community driven by the common goal (Mertler, 2020). This study was specific to STEM educators and their perceptions of female students in STEM education at Skyler High School. An additional limitation of the study included not interviewing or surveying students, due to district regulations, on their perceptions of gender bias in STEM education. This study could have been improved by adding student voices to expand the overall perceptions of STEM education at Skyler High School. Because action research aims to improve and understand situations in which practice takes place (Mertler, 2020), the perceptions from a student’s point of view could have potentially increased the overall validity of this action research study.

**Limitations Associated with Findings**

Researcher bias is a limitation of action research. As a STEM educator myself, the study’s participants may have not disclosed their personal biases about gender resulting in potential responses aligned with a more neutral response. Action research can blur boundaries because the researcher is also a practitioner and colleague of the participants in the research (McAteer, 2013). The surveys were disturbed online which could have
excluded potential participants who are not technology savvy (Yale & Kumar, 2016). For this action research study multiple qualitative methods were used, and peer debriefing was conducted to decrease the influence of any researcher bias in the study.

The lack of diversity among participants in the study was a limitation because all the participants were Caucasian, and five out of 14 participants were female STEM educators teaching mathematics STEM courses. Cultural bias could also have been present with participants due to being asked about culture influences, resulting in them potentially providing more positive responses (Gelling & Munn-Giddings, 2011). This research study will be presented at an international conference in Orlando to decrease the cultural bias of research. Presenting the findings of the study will communicate the research outcomes and recommendations to experts in the STEM education field, also to gain feedback from other researchers on STEM education and future research endeavors.
REFERENCES


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https://doi.org/10.3389/fpsyg.2017.01193


https://journals.co.za/doi/abs/10.10520/EJC153692


https://doi.org/10.1088/1742-6596/1646/1/012011


APPENDIX A
PERCEPTIONS OF STEM PARTICIPANT SURVEY

Read each statement and mark your response in a Likert-Scale with the ratings of: (1) Strongly Disagree, (2) Disagree, (3) Neither Disagree or Agree, (4) Agree, and (5) Strongly Agree. Question 16 is an open-ended question, please respond with 2-3 sentences. Question 17-23 will ask demographic information to answer about yourself.

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Disagree nor Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Female students face significant biological barriers to successfully complete a high school level STEM program. (Environmental-Educational)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Gender is a contributing factor related to successful completion of a high school level STEM course. (Individual-Self-Determination)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Female high school students lack the curiosity needed to be successful in STEM high school courses. (Environmental-Educational)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Female students face significant cultural barriers to successfully complete a high school level STEM program? (Environmental-Educational)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
4. As compared to high school males, females should take more math classes to better be prepared for college level STEM courses.
5. High school female students’ personal life choices could prevent successful completion of high school STEM courses. (Individual- Self-Efficacy)
6. High school females have less support at home, as compared to males, to successfully complete high school level STEM courses. (Environmental- Parental)
7. Females are less likely to work in computer science, physics, or mathematics careers compared to males.
8. Females are more successful in interactive science fields, such as the behavioral or medical fields.
9. Females need a different social environment than males, which creates challenges in competitive male dominated STEM paths. (Behavior-Social Roles)
10. High school females receive higher grades from female STEM teachers rather than from a male STEM teacher.
11. High school female students would benefit from taking additional math courses.
12. Female high school students should take advanced rigorous STEM courses in high school.

133
school to better prepare them for college level STEM programs.
13. High school female students pursuing a STEM pathway would benefit from having a female STEM mentor. (Behavior- Social Influences)

14. Female high school students are less likely to pursue a STEM pathway as compared to male students in high school.

15. In context to STEM programs and careers, where do STEM teachers perceive female high school STEM students in the future? Please explain.

16. Gender

<table>
<thead>
<tr>
<th>Female</th>
<th>Male</th>
<th>Prefer not to answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

17. Ethnicity

<table>
<thead>
<tr>
<th>White</th>
<th>Black or African American</th>
<th>American Indian or Alaska Native</th>
<th>Asian</th>
<th>Native Hawaiian or Other Pacific Islander</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

18. Age

<table>
<thead>
<tr>
<th>20-25</th>
<th>26-30</th>
<th>31-40</th>
<th>41-50</th>
<th>51 or older</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
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</table>

19. Highest level of education

<table>
<thead>
<tr>
<th>Bachelor</th>
<th>Masters</th>
<th>Masters +30</th>
<th>Doctoral Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
20. Year(s) of Teaching STEM courses

<table>
<thead>
<tr>
<th></th>
<th>1-4</th>
<th>5-8</th>
<th>9-12</th>
<th>13-16</th>
<th>17 or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

21. Did you receive an additional certification to qualify to teach a STEM course?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
</tbody>
</table>

22. STEM course(s) currently teaching

<table>
<thead>
<tr>
<th></th>
<th>Science</th>
<th>Technology</th>
<th>Engineering</th>
<th>Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
APPENDIX B

PERMISSION TO ADAPT PERCEPTIONS OF STEM PARTICIPANT SURVEY

Re: Research Instrument Request

Greg Londot
Fri 2/11/2022 6:51 PM
To: KIRKLAND, HALEIGH

1 attachments (13 KB)
research prospectus.docx;

I love your prospective research questions! I will grant you usage with appropriate credit.

Good luck on your adventure!

Greg Londot, EdD
Sent from my iPhone
APPENDIX C
SEX TYPING OF OCCUPATIONS SURVEY

DIRECTIONS: The questionnaire consists of 27 items rated on a 7-point bipolar Likert scale with the endpoints “masculine” and “feminine.” Items in the survey are occupations please select how you perceive the occupation as a masculine occupation or feminine occupation.

<table>
<thead>
<tr>
<th>Occupations</th>
<th>Masculine</th>
<th>Feminine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer programmer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychologist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistician</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dentist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physician assistant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthodontist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dental hygienist IT manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Registered nurse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treasurer</td>
<td>Chemist</td>
<td>Architect</td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
<td>-----------</td>
</tr>
<tr>
<td>Microbiologist</td>
<td>Zoologist</td>
<td>Network administrator</td>
</tr>
<tr>
<td>Aeronautics</td>
<td>Waste management</td>
<td>Land surveyor</td>
</tr>
<tr>
<td>Oceanographer</td>
<td>Forensic scientist</td>
<td>Radiologic technologist</td>
</tr>
<tr>
<td>Medical laboratory technician</td>
<td>Air traffic controller</td>
<td>Computer support specialist</td>
</tr>
</tbody>
</table>
### APPENDIX D

**SCORING OF THE SEX TYPING OF OCCUPATIONS SURVEY**

<table>
<thead>
<tr>
<th>Feminine Occupations</th>
<th>Masculine Occupations</th>
<th>Neutral Occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>Zoologist</td>
<td>Land surveyor</td>
</tr>
<tr>
<td>Certified nursing assistant</td>
<td>Network administrator</td>
<td>Forensic scientist</td>
</tr>
<tr>
<td>Psychologist</td>
<td>Aeronautics</td>
<td>Air traffic controller</td>
</tr>
<tr>
<td>Physician assistant</td>
<td>Computer programmer</td>
<td>Computer support specialist</td>
</tr>
<tr>
<td>Dental hygienist</td>
<td>Mechanical Engineer</td>
<td>Waste management</td>
</tr>
<tr>
<td>Registered nurse</td>
<td>Statistician</td>
<td></td>
</tr>
<tr>
<td>Oceanographer</td>
<td>Dentist</td>
<td></td>
</tr>
<tr>
<td>Radiologic technologist</td>
<td>Orthodontist</td>
<td></td>
</tr>
<tr>
<td>Medical laboratory technician</td>
<td>IT manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treasurer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chemist</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Architect</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Microbiologist</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX E
DRAW A STEM STUDENT

Instructions: Close your eyes and imagine a STEM student at work. In the space below, draw what you imagined.

Draw Here

1. Describe what the student is doing in the picture. Write at least 2 sentences.

2. List three words that come to mind when you think of this STEM student.

3. What kinds of things do you think this student does on a typical day? List at least three things.
APPENDIX F

SEMI-STRUCTURED INTERVIEW GUIDE PROTOCOL

Introductory Script

Thank you for agreeing to meet with me today. I have scheduled an hour for the interview. I want to honor our time constraints; therefore, I may redirect you at times to ensure we cover all the items to be discussed at this time. I also want to make you aware that this discussion is being recorded so I have an accurate recall of responses when evaluating my data.

I am interested in examining STEM educators’ perceptions on high school female enrollment in STEM education courses and the factors that contribute to the enrollment of female high school students in STEM courses.

1. What social norms, if any, do you perceive to affect the enrollment of high school female students in STEM courses?
2. What are your thoughts about societal pressures, if any, that influence the decision-making of high school female students in taking STEM courses?
   a. Share with me an example about how societal pressures, if any, influence the decision-making of high school female students in taking STEM courses?
3. What are your perceptions, if any, about gender stereotyping in the STEM areas?
4. Gender stereotyping means an overgeneralization of traits, differences and qualities based on gender. Share with me what you think about gender stereotyping in STEM areas?
   a. (Follow up) What are your perceptions for why females at Skyler High School take more AP health science track courses or enroll in HOSA (Future Health Professionals) and other medical societies offered by the Career and Technology campus.
5. Let’s talk briefly about curriculum bias, meaning real or perceived bias in the educational curriculum involving diverse, equitable, and inclusive examples. What is your perception about curriculum bias influencing females at Skyler HS from participating in STEM courses?
   a. (If yes) At what grade do you think curriculum bias is present?
6. What are your perceptions about the influence of female self-efficacy in STEM occupations?
7. What do you perceive needs to change during the recruitment of middle school females into the Skyler High School STEM education program?
   a. (Follow up) What do you think could be improved upon to better support female interest in taking STEM courses?
8. Share with me what you perceive to be the biggest barrier for why females at Skyler High School do not enroll in STEM courses?
   a. (Follow up) Why do you believe _________ is a barrier?

**Conclusion Script**
Thank you for participating in my dissertation research interview. Is there anything additional you would like to share about my research focus on low female student participation in STEM courses at Skyler HS? I would like to reiterate that the information that you have shared with me today is confidential when producing the transcript for research purposes.
INVITATION LETTER AND CONSENT FORM

INVITATION LETTER

Dear STEM Educator,

My name is Haleigh Kirkland. I am a doctoral candidate in the Education Department at the University of South Carolina. I am conducting a research study as part of the requirements of my degree in Doctor of Education in Curriculum and Instruction, and I would like to invite you to participate. This study is sponsored and funded by the University of South Carolina.

I am studying STEM education teachers’ perceptions of low female enrollment in STEM courses. If you decide to participate, you will be asked to complete an online Perceptions of STEM Participant Survey, Draw A STEM Student, Sex Typing Occupation survey and meet with me for an interview about perceptions on gender bias in STEM Education.

You will be asked questions about perceptions of gender bias in STEM Education. You may feel uncomfortable answering some of the questions. You do not have to answer any questions that you do not wish to answer. The interview will take place at a mutually agreed upon time and place and should last about 45 minutes. The interview will be audio recorded so that I can accurately transcribe what is discussed. The tapes will only be reviewed by members of the research team and destroyed upon completion of the study. Participation is confidential. Study information will be kept in a secure location at the University of South Carolina. The results of the study may be published or presented at professional meetings, but your identity will not be revealed. So, please do not write your name or other identifying information on any of the study materials.

We will be happy to answer any questions you have about the study. You may contact me at kirklanh@email.sc.edu or my faculty advisor.

Thank you for your consideration. If you would like to participate, please complete the Google Form Survey, Draw A STEM Student and Sex Typing of Occupation Survey. When you are done, please email kirklanh@email.sc.edu to discuss participation.

With kind regards,
Haleigh N. Kirkland
kirklanh@email.sc.edu
CONSENT FORM

UNIVERSITY OF SOUTH CAROLINA CONSENT TO BE A RESEARCH SUBJECT

STEM Educators’ Perceptions of Gender Bias and the Contributing Factors That Persist for Women in STEM Education

KEY INFORMATION ABOUT THIS RESEARCH STUDY:

You are invited to volunteer for a research study conducted by Haleigh N. Kirkland. I am a doctoral candidate in the Department of Education at the University of South Carolina. The University of South Carolina, Department of Education, is sponsoring this research study. The purpose of this study is to understand STEM education teachers’ perceptions of low female enrollment in STEM courses. You are being asked to participate in this study because you are a STEM Educator. This study is being done at Skyler High School and will involve approximately 65 volunteers.

The following is a short summary of this study to help you decide whether to be a part of this study. More detailed information is listed later in this form.

The expected duration of the subject’s participation is approximately two weeks. The participants will be asked to complete an online Perceptions of STEM Participant Survey with Draw A STEM Student activity and Sex Typing of Occupation Survey. The participants will also be asked to participate in an interview that will last approximately 45 minutes at the research location. Taking part in this study is not likely to benefit you personally. However, this research may help researchers understand.

PROCEDURES:

1. Complete a Perceptions of STEM Participant Survey about STEM educators’ perceptions of female high school students’ participation in STEM education, including the factors that influence female high school students to enroll in STEM education.
2. Complete a Sex Typing of Occupation survey about STEM educators’ perceptions of STEM occupations.
3. Complete an interview about perceptions of female high school students’ participation in STEM education, including the factors that influence female high school students to enroll in STEM education.
4. Have your interview recorded to ensure the details that you provide are accurately captured.

DURATION:

Participation in the study involves one interview that will last about 45 minutes.
RISKS/DISCOMFORTS:

There is the risk of a breach of confidentiality, despite the steps that will be taken to protect your identity. Specific safeguards to protect confidentiality are described in a separate section of this document.

BENEFITS:

Taking part in this study is not likely to benefit you personally. However, this research may help researchers understand STEM educators’ perceptions of female high school students’ participation in STEM education, including the factors that influence female high school students to enroll in STEM education.

COSTS:

There will be no costs to you for participating in this study other than possible costs related to transportation to and from the research site.

PAYMENT TO PARTICIPANTS:

You will not be paid for participating in this study.

CONFIDENTIALITY OF RECORDS:

Information obtained about you during this research may be published, but you will not be identified. Information that is obtained concerning this research that can be identified with you will remain confidential to the extent possible within State and Federal law. The investigators associated with this study, the sponsor, and the Institutional Review Board will have access to identifying information. All records in South Carolina are subject to subpoena by a court of law. Study information will be securely stored in locked files and on password-protected computers.

CONFIDENTIALITY CERTIFICATE:

To help us protect your privacy, we have obtained a Certificate of Human Research of Social & Behavioral Researchers Certificate through CITI Program. The researchers can use this Certificate to legally refuse to disclose information that may identify you in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings, for example, if there is a court subpoena.

VOLUNTARY PARTICIPATION:

Participation in this research study is voluntary. You are free not to participate, or to stop participating at any time, for any reason without negative consequences. In the event that
you do withdraw from this study, the information you have already provided will be kept in a confidential manner. If you wish to withdraw from the study, please call or email the principal investigator listed on this form.

I have been given a chance to ask questions about this research study. These questions have been answered to my satisfaction. **If I have any more questions about my participation in this study, I am to contact Haleigh N. Kirkland email**

Concerns about your rights as a research subject are to be directed to, Lisa Johnson, Assistant Director, Office of Research Compliance, University of South Carolina, 1600 Hampton Street, Suite 414D, Columbia, SC 29208, phone: (803) 777-6670 or email: LisaJ@mailbox.sc.edu.

I agree to participate in this study. I have been given a copy of this form for my own records.

If you wish to participate, you should sign below.

________________________________________________________
Signature of Subject / Participant Date

________________________________________________________
Signature of Qualified Person Obtaining Consent Date
**IRB Approval Letter**

**Study application has been approved**

EIRB-Notification@eirb.healthsciencescc.org <eIRB-Notification@eirb.healthsciencescc.org>

5/13/2022 3:34 PM

To: KIRKLAND, RAELISH

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**LETTER PREPARED**

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<th>Pro00120064</th>
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</tr>
<tr>
<td>Review Type</td>
<td>Exempt</td>
</tr>
<tr>
<td>PI</td>
<td>Haleigh Kirkland</td>
</tr>
<tr>
<td>Description</td>
<td>The correspondence letter for this study application has been prepared and has been uploaded to eIRB. To navigate to the project workspace, click on the above ID.</td>
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</table>
## APPENDIX H

### DRAW A STEM STUDENT ARTIFACT INDICATORS AND DESCRIPTIVE

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Descriptive</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>&quot;The physical appearance or attire that the drawing is showing&quot;</td>
<td>● lab coat</td>
</tr>
<tr>
<td>Symbols of research/scientific</td>
<td>“Instruments provide ways of looking at, understanding, and telling others about the natural world”</td>
<td>● eyeglasses</td>
</tr>
<tr>
<td>instruments</td>
<td></td>
<td>● facial hair</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● a globe</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● chemical glassware (beaker, flask, funnel, test tubes, dropper)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● microscope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Bunsen burner, clocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● sink/faucet,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● apparatus (tongs, forceps, clamps, measuring scale)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● chalkboard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● computer programming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● face shield/protective eyewear</td>
</tr>
<tr>
<td>Symbols of Knowledge</td>
<td>“Symbols that show knowledge through book smart, education or instruments used when researching”</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● books</td>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>● clipboards</td>
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</tr>
<tr>
<td></td>
<td>● pens in pocket</td>
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</tr>
<tr>
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<td>● calculator</td>
<td></td>
</tr>
<tr>
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</tr>
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<td>Technology products</td>
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</tr>
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<td></td>
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<td></td>
<td>● Phone</td>
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<td></td>
<td>● Keyboard</td>
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<tr>
<td></td>
<td>● Missiles</td>
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<tr>
<td></td>
<td>● Computers</td>
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<td></td>
<td>● laptops</td>
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<tr>
<td>Dimensions of diversity</td>
<td>“A way to categorize the drawing by diversified elements through attributes of the image”</td>
<td></td>
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<tr>
<td></td>
<td>● Gender (male, female)</td>
<td></td>
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<tr>
<td></td>
<td>● Ethnicity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● age (young or old)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Mythic stereotypes</td>
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</tbody>
</table>
| Environment | "The space or environment that is displayed in the artifact, the physical location shows through the drawing" | ● Scientific laboratory  
● Classroom  
● Outdoors  
● Signage/Signs included |
|-------------|------------------------------------------------------------------------------------------------|--------------------------------------------------|