Teacher Perceptions of the Gender Gap in STEM Education: A Basic Qualitative Study

Danielle Andreula

Dissertation Submitted to the Doctoral Program

Of American College of Education

In partial fulfillment of the requirements for the degree of

Doctor of Education in Curriculum and Instruction

September 2023

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Danielle Andreula

Approved by:

Dissertation Chair: Joshua Strate, EdD

Committee Member: Crystal Neumann, EdD

Abstract

For many years, there have been discrepancies between masculine and feminine populations in science, technology, engineering, and mathematics (STEM) fields. The problem was the gender disparity in middle and high school STEM classrooms, in which teachers often lack an understanding of the underlying reasons and measures needed to lessen the gender gap. The purpose of the basic qualitative study was to explore central New Jersey middle and high school teachers' perceptions of the gender gap in STEM classrooms to determine possible means of lessening the gap. Most of the literature pertaining to the gender gap was gathered from the perspective of students and their feelings towards the gender gap, so this research literature aimed to close the gap by understanding perceptions from STEM teachers' perspectives. The gender schema theory helped to analyze research data and answer the research questions. Two research questions were developed to unveil: (a) teachers' perceptions about the gender gap in STEM, and (b) the strategies used to address the gender gap and engage girls in STEM. A sample size of 23 STEM teachers was used to collect qualitative data via open-ended questionnaires and semi-structured interviews. Thematic analysis divulged six themes including confidence levels, stereotypes, maturity and motivation, external influences, building comfort and confidence, and female role models and representation. Results expressed that teachers have gendered perceptions about girls in STEM, and there is a recommendation to improve teaching approaches in STEM so that educators can effectively engage girls in STEM and narrow the gender gap.

Keywords: STEM, gender gap, perceptions, stereotypes, STEM engagement

Dedication

The first people that must be recognized are my parents Gigi and Joe, and my sisters Gianna and Jessica, for believing in me throughout this whole process and supporting me during the countless hours and nights working to complete my studies. They are some of my biggest supporters and I couldn't have done it without them.

My best friend and significant other, Adin, who reassured me over and over that I would be able to accomplish this goal, even when I was unsure that I would be able to myself. Thank you so much for continuing to support me even when you were stationed and deployed far away from me.

My Aunt Pamela and Uncle Harold, who were some of my biggest cheerleaders since the day I began my journey at American College of Education. Thank you for always keeping in touch with me and asking for updates about the dissertation process. You made my journey more exciting and less stressful, and that is something I will always be grateful for.

My dear friend, classmate, and colleague, Natalina, who I experienced my first years teaching and entire schooling at American College of Education with, including our Master's program. I am not sure how I would have managed to do this without you making light of some stressful situations and answering all of my questions, and that is something I will cherish forever.

Finally, I want to thank my grandfather, Carl, for pushing me to complete my doctoral degree. He was the person who persuaded me to step out of my comfort zone and strive to obtain a degree that not many people can say they have. I love you very much and I appreciate your support along this journey.

Acknowledgements

I want to thank my Dissertation Chair, Dr. Joshua Strate, for his guidance through the entire dissertation process. Your expertise and input from start to finish has helped me achieve my goals and persevere through the difficult and stressful times.

I also want to thank my committee member, Dr. Crystal Neumann, with her consistent encouragement through the process. The support from both my chair and committee member made this journey both very successful and memorable.

Table Of Contents

Chapter 1: Introduction 12
Background of the Problem 14
Statement of the Problem 15
Purpose of the Study 16
Significance of the Study 18
Research Questions 19
Theoretical Framework 19
Definition of Terms 20
Assumptions 21
Scope and Delimitations 22
Limitations 23
Chapter Summary 25
Chapter 2: Literature Review 26
Literature Search Strategy 27
Theoretical Framework 28
Gender Schema Theory 29
Research Literature Review 30
History of Girls in Education and STEM 31
1600s-1700s 31
1700s-1800s 32
Progressive Era Education 32
World Wars and Cold War 32

Equitable Education and STEM Participation in the United States 33
Present-Day STEM Gender Gap in the United States 34
Barriers That Women and Girls Face in STEM Fields 35
Barrier 1: Stereotype Threat for Girls and Women in STEM 35
Barrier 2: STEM Stereotypes Negatively Influencing Girls and Women 36
Barrier 3: "Chilly Climate" in STEM 40
Barrier 4: Family Building and Relationships While in the STEM Field 42
Barriers Related to Perceptions 43
STEM Perceptions from Important Spheres of Influence 44
Girls' Self-Perceptions in STEM 44
Teacher Perceptions 45
Shifting Perceptions 47
Informal Teaching Practices to Engage Girls and Closing the Gap in STEM 47
Role Models and Mentors 48
Early Immersion and Intervention 48
Adding the "A" for STEAM 49
Training and Education on Biases 50
Inclusive and Diversified Instruction 51
STEM Experiences Outside of School 51
Gap in Literature 52
The Need for Girls in STEM 54
Chapter Summary 54
Chapter 3: Methodology 56

Research Methodology, Design, and Rationale ... 57
Methodology ... 57
Design ... 57
Role of the Researcher ... 58
Research Procedures ... 59
Population and Sample Selection ... 59
Questionnaires ... 61
Semi-Structured Interview ... 61
Subject Matter Experts ... 62
Data Collection ... 63
Data Analysis ... 64
Reliability and Validity ... 65
Ethical Procedures ... 66
Chapter Summary ... 68
Chapter 4: Research Findings and Data Analysis Results ... 69
Data Collection ... 69
Data Analysis and Results ... 71
Participant Demographics ... 71
Thematic Analysis ... 75
Findings for RQ1 ... 80
Findings for RQ2 ... 82
Reliability and Validity ... 85
Chapter 5: Discussion and Conclusions ... 88

Limitations ... 94

Recommendations ... 96

Implications for Leadership ... 98

Conclusion ... 101

References ... 103

Appendix A ... 120

Appendix B ... 121

Appendix C ... 124

Appendix D ... 125

Appendix E ... 126

Appendix F ... 129

Appendix G ... 130

List of Tables

1. Emergent Codes and Associated Themes ………………………………………………. 76

2. Research Question Theme Anlignment ………………………………………………… 83

List of Figures

1. Participants' Years Teaching …………………………………………………….... 72

2. Participants' STEM Subject Area ………………………………………………..... 73

3. Participants' Gender Identity ……………………………..………………………… 74

4. Participants' Grade Level Teaching 75

5. Findings and Themes from RQ1 …………………………………………………..… 82

6. Findings and Themes from RQ2 …... 84

Chapter 1: Introduction

Science, technology, engineering, and mathematics (STEM) education has increasingly become the cornerstone of K-12 curricula around the world. Globally, countries are turning to STEM education and recognizing the implementation of STEM pedagogy as fundamental to national development and productivity, economic competitiveness, and societal well-being (Freeman et al., 2019). With STEM becoming a prominent force in the field of education, it is important to consider accessibility and equity in STEM for all students. According to Nagdi and Roehrig (2019), the underrepresentation of girls and women in STEM is evident in at least 50 countries around the world, making the gender gap in STEM a global issue for post-industrial and developing countries. The disproportionate population of girl and boy students participating in STEM subjects has left stakeholders perplexed regarding the causes of this phenomenon.

The gender gap in STEM is a recurring issue that educational professionals seek to find solutions for and further understand. Since the gender gap in STEM continues to create a setback for girls seeking STEM career paths, researchers have gathered data to understand and draw conclusions on why these discrepancies exist, and to figure out the changes that should be made in education to close the gender gap in STEM areas. The data collected on the gender gap in the STEM field show that only 20% of bachelor's degrees in physics and science were awarded to women in the United States, and only 35% of degrees in all STEM fields were awarded to women (Nagdi & Roehrig, 2019). These statistics trickle down to the younger age groups, where most children from kindergarten to high school perceive scientists and STEM-related careers as occupations that are masculine (Makarova et al., 2018).

Being aware of the current STEM statistics and perceptions of students can help to further study the gender gap in STEM. Continuing research on the gender gap in STEM has numerous benefits such as helping all who work in the entire field of education become more aware of the gender gap to instill an understanding of how to better engage girl students in STEM. According to Makarova et al. (2018), girl students in K-12 education have a strong masculine image of math and science, which decreases the likelihood of choosing a STEM major at university. Knowing that girls have these perceptions that begin at an early age epitomized the importance of furthering this research and educating teachers in the field. Educational professionals may benefit from this research to understand how specific instructional strategies can be implemented to mediate gender stereotypes and the gender gap in STEM classrooms. Addressed in Chapter 1 are the background of the problem, the statement of the problem, the purpose of the study, the significance of the study, the research questions, the theoretical framework, the definition of terms, the assumptions, the scope and delimitations, the limitations, and the chapter summary.

Background of the Problem

Throughout history, women and men have endured vastly different experiences regarding their reception into the STEM community. According to the College of St. Scholastica (2015), women throughout history have made groundbreaking discoveries that have revolutionized the understanding of the world, and STEM concepts yet have gone with little to no recognition. At some universities such as Cambridge in the 1920s, degrees were not even granted to women after program completion (The College of St. Scholastica, 2015). It was not until the passing of Title IX that school and university administrators started to implement real reform for girls in educational settings. According to Cohen (2021), Title IX bans any educational institution from discrimination based on sex.

With the reform initiatives to help girls advance in STEM subjects, there remain differences in the boy and girl populations. According to Flair (2021), STEM occupations, such as computer science, are made up of only 27% of women, whereas in other professional occupations, women make up 57% of the population. It has been postulated that these gender discrepancies in the STEM field are being attributed to various barriers such as stereotype threat, sexism and gender bias, interest levels, and a chilly climate towards women in the field (Jensen & Deemer, 2019). With these obstructions to girls and women getting involved in STEM, school and district officials have taken it upon themselves to help alleviate the gender gap in STEM. Strategies to engage girls in STEM such as introducing role models and mentors, immersion, and intervention, diversified and differentiated STEM instruction, and informal STEM experiences have been used to help the gender gap issue (Kinskey, 2020). The further issue is that the STEM gender gap is lacking attention at the formal instructional level in middle and high schools.

Statement of the Problem

The problem was there is a gender disparity in middle and high school STEM classrooms, in which teachers often lack an understanding of the underlying reasons and measures needed to lessen the gender gap. Middle and high school STEM classrooms having a gender gap is a problem because the disproportion begins during those developmental years and continues into post-secondary schooling where women are the minority in STEM majors (Sansone, 2019). In fact, middle and high school girls are choosing to avoid high-level STEM courses altogether. In K-12 education, advanced placement (AP) STEM subjects such as physics and computer science are more likely to be populated by students who are boys than students who are girls, as the enrollment rates of boys are typically higher (Sansone, 2019). According to the American Association of University Women (AAUW, 2022), girls and women are tracked away from science and math throughout their education, which limits their access and motivation to participate in STEM fields. Limited STEM participation from girls leads to negative consequences at the occupational level, resulting in women making up only 28% of the workforce in STEM fields (AAUW, 2022).

Those impacted by the gender gap problem are middle and high school STEM teachers. According to Hayes (2021), many girls who have positive attitudes toward math and science at a younger age tend to lose interest and self-confidence in STEM by age 14. The foundational years that are meant to pique girls' interest and help them pursue their academic passions into high school and college are dampened with poor self-perceptions of STEM ability. Increasing middle and high school teachers' awareness of the STEM gender can help create initiatives and changes that will develop girls' confidence and involvement in STEM subject areas. One of the first steps that can be taken to promote awareness and knowledge of the STEM gender gap would be to equip STEM teachers with the proper instructional strategies and practices that have shown success in engaging girls in STEM. This may also start with first gathering information from middle and high school STEM teachers about their current perceptions and knowledge of the gender gap. Middle and high school STEM teachers' perceptions can provide crucial information about current STEM instructional practices and strategies for adjusting their practices to increase girls' enticement in STEM. To address the gap in the literature for this problem, the gender gap in STEM from middle and high school teachers' perspectives must be considered.

Purpose of the Study

The purpose of this basic qualitative study was to explore central New Jersey middle and high school teachers' perceptions of the gender gap in STEM classrooms to determine possible means of lessening the gap. Twenty-three middle and high school STEM teachers served as the participants in this study, with all other subject area teachers excluded as potential participants. The qualitative approach was chosen because qualitative data can add essential information about a given setting, which can lead to more relevant and actionable solutions to a problem (Alexander et al., 2020). Conducting this study helped identify the current strategies that middle and high school teachers use to engage girls in STEM, and their general perceptions of the gender gap in their STEM classrooms. This study may help spread awareness to all school stakeholders, including administration, teachers, students, and parents, which can help reduce the gender gap in STEM classrooms. If this research was not conducted, middle and high school STEM classrooms would continue to experience a gender disparity, and teachers will lack the proper knowledge and awareness to increase STEM interest and engagement in the girl population. Contributions were made to the current knowledge base regarding teachers' perceptions of the gender gap in STEM classrooms by relaying and interpreting qualitative data gathered from middle and high school STEM teachers. Qualitative data were collected through open-ended questionnaires and semi-structured interviews.

Many studies regarding the gender gap in STEM often relied on the perceptions of students, and not the perceptions of teachers (King & Pringle, 2019). Current research is limited regarding perceptions specifically gathered from middle and high school STEM teachers. From this study, collected data were used to assess what instructional practices middle and high school STEM teachers implement in their classrooms to determine why the gender gap exists. To further support closing the gender gap and helping teachers understand the urgency of increasing girls' engagement in STEM, information from this study was shared with school leaders who implement STEM programs. Sharing information during professional development and instructional training in STEM will help middle and high school STEM teachers build knowledge and understanding of the gender gap and how to intervene in it. As a result of the study, middle and high school STEM teachers were able to understand how to utilize practices and strategies in their classrooms to effectively inspire and encourage girls to participate in STEM, ultimately closing the gender gap.

Significance of the Study

Conducting this study was necessary to explore teachers' perceptions of the gender gap in middle and high school STEM classrooms. Collecting data from 23 teachers about their views on the gender gap present in their STEM classrooms helped identify the shortcomings in current curricular practices and subsequently adjusted practices to help increase girls' engagement in STEM. In the past, articles have been written regarding teachers' and students' perceptions of gender bias, sexism, and stereotypes toward girls in STEM (Hand et al., 2017; Moss-Racusin et al., 2018). There were remaining curiosities about how teachers utilize formal instruction to break down those barriers and meet the needs of girls to increase participation, interest, and engagement in STEM classes. Conducting this study was essential to find meaning behind the phenomena of the persistent gender gap in STEM classrooms.

All stakeholders involved in education may benefit from the results of this research including the department of education, administrators, teachers, students, and parents. Department of education can now adjust state and national mandated learning standards in STEM subjects to help increase engagement for girls. In addition, administrators and teachers can enhance their curriculum and lessons with strategies identified that will increase engagement from girls in their STEM classrooms. Lastly, parents and students may benefit because parents will have the knowledge and tools to help their children get involved in STEM, and girls will reap the benefits of their schools adjusting instruction to help them realize their potential for a future in STEM.

Research Questions

In this study, teachers' perceptions of the gender gap in middle and high school STEM classrooms were examined. This study helped determine how middle and high school STEM teachers view the gender gap in STEM and the strategies they utilize to engage girls in STEM. Research questions for this study were designed and structured strategically to align with the problem, purpose, and data collection methods within the intended study. Two research questions were developed to draw data about perceptions that STEM teachers hold regarding the gender gap in their classrooms. The following research questions guided the study:

Research Question 1 (RQ1): What are teachers' perceptions about the gender gap in STEM education?

Research Question 2 (RQ2): What strategies do teachers use to address the gender gap and engage girls in STEM education?

Theoretical Framework

The gender schema theory was the theoretical framework that steered the study. Bem developed the gender schema theory in 1981, which falls under the larger umbrella of social-cognitive theory (Zukauskas, 2021). According to Starr and Zurbriggen (2017), the gender schema theory insinuates that individuals in society become gendered from an early age and make decisions in life based on what they deem masculine or feminine. In past studies, researchers connected the gender schema theory to guide research in seeking to understand why girls oppose the pursuit of STEM fields, and how gender stereotypes can impact girls' participation in STEM careers (Brewer & Ley, 2017).

One of the major factors and reasons why the gender schema theory drove this study is that it was used to help middle and high school teachers understand their students' learned perceptions and implement ways to change their gendered beliefs about STEM subjects. Kollmayer et al. (2018) explained that gender schema theory assumes that gender typing is a learned phenomenon and is neither inevitable nor unmodifiable. Children observe their environment and culture to learn about masculinity and femininity, along with the societal roles and treatment of different genders in their surroundings (Kollmayer et al., 2018). Since children develop their gender schemas through observing and learning from the world around them, this can also mean that teachers can influence and re-teach them to understand they can pursue school subjects and careers that society once deemed to be masculine. The gender schema framework relates to the study because gender schema is learned, and teachers can play a vital role in reshaping students' beliefs about their capabilities in the STEM field.

Gender schema theory helped guide the research questions because considering how gender schema impacts a classroom helped develop points of inquiry for teachers in STEM subjects to reflect on their own experiences and perceptions of the STEM gender gap phenomena. Data analysis was also guided by the gender schema theory because teachers may also be impacted by their schemas of gender. STEM teachers already have pre-developed gender schemas that were considered when collecting and analyzing data. More information on the gender schema theory and the rest of the theoretical framework is detailed in Chapter 2.

Definition of Terms

Throughout this research, key concepts and constructs were discussed using specific terms relevant to the study topic. Providing the terms and definitions within this study helped to intuitively understand the various discussions presented and will also help any reader cohesively understand the content. The following terms were defined for reader use:

Gender is defined as a biological or social/cultural construct that the environment poses on an individual, including what is considered male or female (Kans & Claesson, 2022).

Gender stereotypes are defined as the automatically activated cognitive connections between a gender group and their attributes such as ability or interests (Block et al., 2022).

STEM education is defined as a teaching approach that combines STEM as an integrative subject area to teach real-world applications and problem-solving (Hom & Dobrijevic, 2022).

STEM engagement is defined as positive experiences that increase activation and success in STEM subjects (Wheeler & Hall, 2021).

STEM gender gap is defined as the under-representation of gender diversity in STEM education, namely of women and girls (Verdugo-Castro et al., 2022).

STEM perceptions are defined as a person's information and understanding of the STEM content area and its importance (Navy et al., 2021).

Assumptions

A critical skill for academic researchers to implement within their research is identifying assumptions. An assumption is a belief one has without realizing they have that certain belief (University of Louisville, 2021). Assumptions are necessary for qualitative research because assumptions guide argumentation, evidence generation, and conclusions (Nkwake, 2013). When it comes to identifying assumptions, the researcher must think critically because assumptions can sometimes be incorrect or misguided (University of Louisville, 2021). One assumption was that participants have experienced a gender gap in their STEM classrooms. This study was based on participants being able to discuss their perceptions of the gender gap in middle and high school

STEM classrooms. If the assumption is incorrect, participants may not have been able to participate in a relevant and accurate manner in the study. The researcher needed to assume that participants have experienced gender gaps in their STEM classrooms to conduct the study. A second assumption was that the teacher participants in this study honestly described their perceptions of the gender gap in STEM classrooms. Depending on the participants' subjective experiences and perceptions of STEM students and the gender gap, they may have felt uncomfortable being fully transparent or may have been unable to directly connect with the questionnaire and interview questions.

Scope and Delimitations

A scope within a research study sets clear parameters for the research (University of Mount Olive, 2019). The objective of the study was to answer research questions through qualitative responses from participants based on their perceptions of the gender gap in middle and high school STEM classrooms. To define the scope of this study, 61 STEM teachers served as the target population, and from that population, 23 STEM teachers encompassed the sample from a middle and high school central New Jersey school district. In addition, the scope included STEM teachers in grades seven through 12. Qualitative data collection was considered for the scope of the study, which included only an open-ended questionnaire and a semi-structured interview that was conducted by the lead researcher.

Delimitations of a study set boundaries so that the research objectives do not become impossible to achieve (Theofanidis & Fountouki, 2018). A delimitation of the study was the number of participants being no larger than 23. The decision to incorporate 23 participants from one central New Jersey school district was intended to maintain focus on the specified population and not oversaturate the data and data collection with too many responses. Another delimitation involved the exclusion of any teachers who do not teach within the district at the middle and high school levels. If participants did not teach in grades seven through 12 or do not teach a STEM subject, they were excluded from participation in the study.

These delimitations of the sample size and participant criteria impacted transferability. The sample of only 23 teachers impacted transferability because the study results may not have been relatable to a larger population of STEM teachers. Participant criteria delimitation also impacted transferability, as the results were based on the responses only of middle and high school teachers, so the study may not be transferrable to other grade levels in STEM subject areas. The outcomes of the study held the most significance to middle and high school STEM teachers' curricular and teaching practices. Results of the study were transferrable to other grade levels and subject areas for the general betterment of girls in education, but the results are most relevant to the population mentioned within the scope and delimitations.

Limitations

Limitations are different than delimitations because limitations are potential weaknesses in a study that are typically out of the researcher's control (Theofanidis & Fountouki, 2018). This study focused on teachers' perceptions of the gender gap in STEM classrooms. Because this study was limited to one school district in the geographical area of central New Jersey, the results cannot be generalized or are not transferrable to every school or district within the state of New Jersey. The method to combat the transferability issue in this study was providing full transparency of the study so that it is replicable within various subject areas, which also increases the reliability of the study (see Coleman, 2021). The basic qualitative methodology and design also had limitations regarding dependability. Dependability refers to the consistency and reliability of research findings and how well they are documented so that an outside researcher would be able to easily follow along (Moon et al., 2016). Dependability can become a limitation in qualitative research due to the length and depth of responses from many participants. To ease the limitation of dependability within this study, every interaction was recorded, whether written records, audio records, or transcripts, to ensure that the finding was fully documented. In addition, all data instruments, packets, and any other protocol utilized within the study are easily accessible.

Other factors that could impact the results of the study included time constraints and participant accessibility. When the study was conducted, participants needed to answer the questionnaire and participate in the interview on time. Time constraints were a limitation because it was possible that not all participants selected were able to meet by the time the researcher needed all results to analyze. Another factor that impacted the results of the study was participant accessibility. According to Dahlke and Stahlke (2020), one of the main requirements of qualitative research is to obtain access to participants. The study took place in a school district that consists of one middle school and one high school. Sixty-one participants who teach STEM subjects were identified and contacted about participation in the study, but the limitation was whether or not the targeted sample of 15 teachers would accept participation in the study. If any of the 15 teachers declined or were unable to participate, the pool of STEM teachers remaining within the specified district was low and decreased accessibility to participants. In the end, 23 STEM teachers agreed to participate in the study, so the sample size issue was averted.

Finally, bias is a limitation of a study that can influence study outcomes. One of the main forms of bias that could have threatened the study was confirmation bias. Bullard (2022) explained that confirmation bias is the inclination to interpret findings selectively so that it reinforces preconceived beliefs. This type of bias was a limitation because the researcher was a woman working in the STEM field, and the study pertains to the gender gap in STEM subject areas. To mitigate and reduce confirmation bias, the researcher used the method of reflexivity. Reflexivity refers to the critical examination of the researcher and self-reflection on the decisions that are made within the study, the information that was included or excluded, and continuous self-analysis and awareness of potential bias (Mirja & Määttä, 2021). Since the researcher consistently used the method of reflexivity, various biases that emerged within the study were identified and alleviated.

Chapter Summary

This basic qualitative study aimed to determine teachers' perceptions of the gender gap in middle and high school STEM classrooms. STEM fields continue to hold a gender gap that has impacted women and girls around the world, and all stakeholders continue to ponder why the gender gap in STEM presently remains. The problem was there is a gender disparity in high school STEM classrooms, and teachers often lack an understanding of the underlying reasons and measures to take to possibly lessen the gender gap. This research is essential and significant because it informs teachers around the world about the teaching strategies that can be implemented to increase engagement for girls in STEM. The research questions and theoretical framework guided the study to help understand STEM teachers' perceptions of the gender gap. Identifying assumptions, the scope of the study, delimitations, and limitations was also essential for quality research. Chapter 2 presents a review of the literature related to this study. The literature review addresses an in-depth explanation of the theoretical framework, the history of girls in education and STEM, equitable STEM education in the United States, barriers that women and girls face in STEM, STEM perceptions, and informal teaching practices to engage girls in STEM.

Chapter 2: Literature Review

The gender gap in STEM is not a new phenomenon, nor is it a sudden realization by those currently in the field. Throughout the past and currently, the gender gap in STEM has been evident and continues to influence women and girls in STEM worldwide. According to Casad et al. (2021), women are underrepresented in STEM fields such as computer science with a population of 18.7%, physical sciences with a population of 19.3%, and engineering with a population of 20.9%. Nevertheless, there is no significant difference in cognitive aptitude between men and women in STEM subjects (Stewart-Williams & Halsey, 2021).

Studies have commonly sought to understand the viewpoints and perceptions of women in the STEM workforce and undergraduate women in STEM majors. Yet, there is a lack of research on middle and high school girls in the STEM classroom. Most of the research available pertains to college-aged women or older in STEM majors about their experiences with stereotype threat, explicit and implicit discrimination, and systemic barriers to their STEM participation (Guy & Feldman, 2021). The literature that does exist about younger girls in middle and high school STEM classrooms is typically collected from students and their perceptions rather than their teachers on how to lessen the gender gap. Jackson et al. (2021) performed a study to gain insight into girl students' perceptions of robotics and STEM before and after a soft-robotics curriculum intervention. Although teachers were involved in the implementation process of this study, only the students' perceptions were gathered about STEM engagement, while the teachers' involvement and perceptions of the gender gap in STEM were not considered.

Even less literature exists on how teachers can adjust formal instruction and classroom practices to engage girls in STEM. Starr and Simpkins (2021) explained that a small amount of research exists on the relationship between teachers' beliefs and perceptions and student indicators in STEM. Most of the literature that exists about strategies to lessen the gender gap in STEM focuses on informal STEM experiences that take outside of school hours to increase participation, interest, and motivation for girls in STEM. The purpose of this basic qualitative approach is to investigate teachers in a New Jersey school district in grades 7 through 12. The research will examine these teachers' perceptions of the gender gap in STEM and will examine how to lessen the gender gap in the STEM classroom.

The chapter includes a description of the literature search strategy for the literature review. In addition, the gender schema theory is detailed in the theoretical framework section and connects concepts and relationships between articles within the literature review, which will guide the study. The literature search strategy, theoretical framework, history of girls in education and STEM, equitable education and STEM participation in the United States, barriers that women and girls face in STEM fields, STEM perceptions from important spheres of influence, informal teaching practices to engage girls and closing the gap in STEM, the gap in the literature, the need for girls in STEM, and the chapter summary will be addressed.

Literature Search Strategy

To aid in the development of this literature review, a variety of databases and search engines were utilized. The primary method of searching for literature was through the American College of Education's (ACE) OneSearch. This was often a preliminary action to find relevant articles to the research topic. From this search, some of the common databases used were Education Resources Information Center, SAGE Journals, Academic Search Complete, Education Source, and EBSCOHost. Google Scholar was another search engine that was frequently used to gain access to additional related articles. To ensure that the articles retrieved from Google Scholar were peer-reviewed, the title of the article was pasted into the ACE

OneSearch and allowed to detect the peer-review status. Peer-reviewed articles were of high-priority when searching for literature. The following keywords, phrases, and search terms were included in the search for literature on the gender gap in STEM including: *STEM*, *gender gap*, *gender inequality*, *gender bias*, *self-efficacy*, *STEM ability*, *perceptions of boys in STEM*, *perceptions of girls in STEM*, *STEM instruction*, *STEM encouragement*, *sexism*, *stereotypes*, *gendered socialization*, *social role theory*, *history of women in education*, *history of women in STEM*, *Title IX, chilly climate in STEM*, *Gender gap in STEM worldwide*, *middle school girls in STEM*, *high school girls in STEM*, *middle school boys in STEM*, *high school boys in STEM*, *strategies to engage girls in STEM*, *teachers perceptions of girls in STEM*, *teacher perceptions of boys in STEM*, *parent influence on students in STEM*, *girls compared to boys in STEM*, *parental involvement in STEM*, *how to help boys accept girls in STEM*, *interventions for girls in STEM*, *STEAM, adding arts into STEM for girls*, *sphere of influence*, *influences on girls participation and interest in STEM*. The use of scholarly, peer-reviewed articles, as well as e-Books, provided material for the current study and helped identify gaps in current knowledge and literature on the gender gap in STEM classrooms from a teacher's perspective.

Theoretical Framework

The gender schema theory was used to develop the theoretical framework. The theoretical framework guided and supported the problem statement, the purpose of the study, and the research questions that addressed the gender gap in middle and high school STEM classrooms. The theoretical framework also established connections and relationships between information that was addressed in the literature review. The gender schema theory provided structure, meaning, and the underlying implication of the research study.

Gender Schema Theory

The gender schema theory was first developed by Sandra Bem in 1981 (Zukauskas, 2021). This social-cognitive theory addresses how individuals in society become gendered from an early age and make decisions in life based on what they deem masculine or feminine (Starr & Zurbriggen, 2017). Other notable works have been published in the early 1980s about gender schema including the *Journal of Personality and Social Psychology* (Crane et al., 1982). One of the major differences between Markus and Bem's work was that Markus theorized gender schemas based on the "self," whereas Bem theorized gender schema as a societal organizing construct (Starr & Zurbriggen, 2017). Bem expanded upon the gender schema theory and posited that sex-typing leads individuals to position themselves in certain ways in society. According to Geldenhuys and Bosch (2020), sex-typing is defined as the process society transmutes male and female into masculine and feminine, meaning that if someone is female, they are expected to follow feminine cultural norms, and if someone is male, they are expected to follow masculine cultural norms, which influences individuals' educational and occupational decision-making.

Previously, the gender schema theory has been applied to understand why girls do or do not choose to pursue STEM, and how gender stereotypes in media can impact girls' participation in STEM careers (Brewer & Ley, 2017). Within the gender schema theory, gender socialization is closely related, which essentially means that boys are conditioned to conform to male gender roles and norms while girls are conditioned to conform to the female gender roles and norms (Reinking & Martin, 2018). The gender schema theory gave rise to research on STEM gender differences and girls' interest and engagement in STEM. Sandra Bem's gender schema theory was used to help organize the study by guiding the exploration of the gender gap in STEM classrooms and whether held gender schemas contribute to the decisions that girls and teachers make in the STEM classroom. The gender schema theory also supported and guided the study by using the theory as a framework to better understand teachers' perceptions of girls' pursuit of STEM and how instructional strategies are implemented to shift gender schemas and close the gender gap in STEM. Gender socialization and Bem's gender schema theory related to the problem and purpose of the study by giving the researcher background knowledge on how individuals' interests, beliefs, and attitudes are formed around gender and social norms. Ultimately, the gender schema theory provided insight into how socialized gender expectations can shape girls' interests and participation in STEM. This theory also helps teachers understand why girls may be avoiding STEM and can help teachers prevent this cycle, help lessen the gap, and encourage more girls to participate in STEM.

Literature Review

Throughout history and into the early 2020s, men and boys have been viewed differently than women and girls from an educational standpoint. These views and psychosocial experiences in middle and high school have caused women and girls to follow a pre-determined path in education and gendered influences on their career trajectories, while men and boys followed a separate path deemed more suitable within a masculine role (Ismatullina et al., 2022). The stereotyped views of girls in STEM education continue, so the purpose of this basic qualitative study was to explore central New Jersey high school and middle school teachers' perceptions of the gender gap in STEM classrooms to determine possible means of lessening the gap. Understanding the barriers that girls face in STEM, girls' self-perceptions in STEM, and teachers' perceptions in STEM was discussed throughout the literature review. The literature also sheds light on details regarding how to lessen this gender disparity in STEM classrooms. The sections addressed within the research literature review include a history of girls in education and STEM, equitable education and STEM participation in the United States, barriers that women and girls face in STEM fields, STEM perceptions from important spheres of influence, informal teaching practices to engage girls and closing the gap in STEM, the gap in the literature, and the need for girls in STEM.

History of Girls in Education and STEM

The experiences that women endured in education throughout history vary greatly from the experiences of men. Men were commonly in positions of power and receiving an education, learning how to read, write, and even obtain degrees. Historically, a woman's position was to maintain the household and bear children (Solomon, 1985). These early positions could have paved the way for the slow progression of women and girls' involvement in education and set the precedent for a masculine-dominated STEM field. The history of girls in education and STEM within the 1600s-1700s, 1700s-1800s, Progressive Era, and World Wars and Cold War will be addressed.

1600s-1700s

In the 1600s, colonial Americans dismissed the notion of women attaining a college education. They believed that women had smaller brains and weaker minds and had no reason to obtain any type of formal education (Solomon, 1985). Compared to other parts of America, New England happened to have some of the more advanced women in academics, where 50% of them knew how to sign their name, and some of that population was taught to read. Most women were encouraged to read through religion, but even then, were expected to be quiet and subservient (Solomon, 1985). During this time, science and mathematics were not a priority for the education of women.

1700s-1800s

Between the 1790s and 1860s, there was a significant advancement in women's schooling, but the primary teachings were Protestantism and the ideology of republican motherhood and not necessarily academic subjects (Su, 2022). The exception to educating women was educating them to become teachers, and by the end of the 1830s, women were the predominant force in the teaching field (Solomon, 1985). Women who were fortunate enough to receive an education in the antebellum era had a longing for intellectual growth and often were exposed to liberal arts and even science (Su, 2022). With the introduction of science and women being allowed to learn, progress was being made for women to begin participating in STEM.

Progressive Era Education

During the progressive era, girls and women were more commonly seen in schools. During this time, there were two types of schools "normal" and "prestigious." In the "normal" schools, women and girls had more freedom to interact with men and partake in similar academic courses. In "prestigious" schools, there were attempts to shape women's social life; therefore, gender differences in academic opportunities were much more apparent (Su, 2022). Towards the end of the 19th century and into the 20th century, women and girls mainly studied liberal arts and home economics, and less of the other academic areas such as science or mathematics (Su, 2022). At that time, science and mathematics were rarely taught to girls in schools compared to the exposure that the boys received.

World Wars and Cold War

With many men overseas during the war, the doors opened for women in education. Solomon (1985) explained that women in the United States gained access to higher education at the start of World War II but were still limited in ability to take STEM courses compared to men.

This would quickly change when peacetime set in and the progress of women in education would come to a halt. In the post-world war era, higher education increased, and so did women's share of higher education (Ro et al., 2021). In 1970, women's share in education was at 10% but was steadily increasing. This steady increase was occurring in fields such as the humanities, social sciences, and education, but not in STEM subjects (Ro et al., 2021).

Equitable Education and STEM Participation in the United States

It was not until the implementation of Title IX that girls and women started to see equity in their education. According to White (2019), various acts have been set in place to ensure gender equality nationally including Title VII of the 1964 Civil Right Act, Title IX of the 1972 Education Amendments Act, and the equal protection clause of the 14th amendment. When congress passed Title IX of the Education Amendments, the use of quotas, sex-specific rankings, and other forms of sex discrimination for admissions to schools was banned (Rim, 2021). Overall, Title IX was meant to provide equity in educational opportunities and close the wage gap between men and women, all having great success. According to Cohen (2021), the first 25 years after Title IX was passed showed progress, with 63% of girls who graduated high school went on to attend college, which was up 20 percentage points compared to 43% in 1973. Concerning STEM subjects, in 1972 when Title IX was enacted, only 9% of women earned medical degrees, and 25 years later in 1994, that number increased to 38%. With the enactment of Title IX and the other women's protection amendments, there has been a major improvement for women in education.

With the implementation of Title IX, the United States saw a steady increase of women in education, even more significantly in STEM fields. Even though Title IX does not directly pertain to specified fields, legislation granted women a voice and opened the doors to equitable opportunities for entering and succeeding in a masculine-dominated career path such as STEM (Butcher et al., 2020). Still, though, it was evident that discrepancies between the different gender’s participation in STEM. Since Title IX was not implemented until 1972, this could explain the slow progression for women in STEM and the current STEM gender gap today. The STEM gender gap in the United States addressed in the next section further explains how the gender gap in STEM continues as a phenomenon in 2022.

Present-Day STEM Gender Gap in the United States

In the United States, the percentage of women graduating with a science degree such as life science, physical science, computer science, and math is about 42%. Engineering degrees are even lower, with women graduates at about 21% (Card & Payne, 2021). In computer science and computing occupations, women make up 27% of the population whereas in other professional occupations, they make up 57% (Flair, 2021). According to the American Association of University Women (AAUW), women make up only 28% of all individuals working in STEM fields (2022). Out of the STEM disciplines that exist, women are mostly biological scientists at 46%, but when it comes to the engineering and architecture discipline, women only make up 16.5% (AAUW, 2022). Stewart-Williams and Halsey (2021) explained that this could be because women are more interested in “individuals” than “things,” so they choose biological science and the medical field with the goal of taking care of patients. Regardless of the STEM discipline that women and men choose, there are clear differences in participation, which could be related to the different experiences women have while participating in the STEM field. Over time, strides have been made toward mending the disparities in STEM, but there are still barriers and obstacles that women face in STEM, which further contribute to the gender gap.

Barriers That Women and Girls Face in STEM Fields

Historically, girls have had a very different experience in STEM classrooms compared to boys. Sansone (2019) explained that women and girls do not hold as much presence as men and boys in physics, computer science, engineering, and mathematics. This lack of presence is an obstacle for women in STEM because it ultimately causes a snowball effect for more girls to continuously opt-out of STEM. Cabell et al. (2021) explained that it is imperative to address these gender disparities in STEM at the middle and high school levels so that girls can engage in higher-level STEM coursework, increase self-efficacy, and increase the population of girls in STEM. Four specific barriers will be covered. The first barrier is the stereotype threat for girls and women in STEM. The second barrier includes STEM stereotypes that negatively influence girls and women. The third barrier addressed in this section pertains to a chilly climate in the STEM field. Finally, the fourth barrier discusses family building and relationships while in the STEM field.

Barrier 1: Stereotype Threat for Girls and Women in STEM

One of the barriers that women and girls face in STEM is stereotype threat. Stereotype threat is the feeling that arises when individuals in the stigmatized group feel anxiety about or are at risk of confirming a negative stereotype (Casad et al., 2021; Lin & Deemer, 2021). The issue is that girls often feel the negative impacts of stereotype threat in STEM, oftentimes about their ability to perform mathematical skills (Fordham et al., 2020). Stereotype threat specifically about girls in STEM causes girls in this targeted group to feel undermined in their STEM performance and avoid the field (Liu, 2018). Additionally, research shows that stereotype threat for girls in STEM is known to be extremely harmful as it has impaired performance, decreased self-efficacy, and even altered career aspirations (Fordham et al., 2020; Lin & Deemer, 2021). These reports of lower self-efficacy persist through increased grade levels, even when there is no evidence of cognitive differences between boys and girls in STEM (Sansone, 2019). When girls report these attitudes and beliefs towards STEM due to negative stereotypes, it discourages them and decreases interest.

Wieselmann, Roehring, et al. (2020) analyzed elementary school girls' beliefs about success and the gender gap in STEM. The findings show that teachers have an influence on how these girls perceive their ability to participate in STEM. Wieselmann, Roehring, et al. (2020) found that the messages educators send, both implicitly and explicitly, to their students have an impact on how students hold stereotypes. Teachers must shift the dialogue to be more accepting of girls in STEM and address gendered stereotypes to prevent girls from feeling the negative impacts of stereotype threat.

Barrier 2: STEM Stereotypes Negatively Influencing Girls and Women

Various forms of stereotypes exist in the STEM field, which becomes a barrier for women. These stereotypes are harmful to the participation rates of women and girls in STEM. The three stereotypes that will be addressed include: (a) girls are not good at math, (b) boys and men are more successful and interested in STEM, and (c) STEM is a career in isolation. Within the heading of boys and men being more successful and interested in STEM, specific sub-stereotypes will be addressed such as the "brilliance" stereotype, gender-interest stereotype, and expectancy.

Girls are Not Good at Math. Stereotypes often create a barrier to women's and girls' STEM interests and participation. Many gendered stereotypes such as girls are not good at math surround the STEM field, even though studies prove that there are no genetic factors that result in girls being inferior to men in this field (AAUW, 2022; Sansone, 2019). By third grade, many girls lose confidence in math, while boys are more likely to say that they are strong in mathematics (AAUW, 2022). Stewart-Williams and Halsey (2021) found that stereotypes about girls' abilities in math commonly discourage them from STEM, even when it is untrue. Research shows that in some circumstances boys perform better in math, in other circumstances girls perform better, and in most cases, there are no overall sex differences in mathematical performance (Stewart-Williams & Halsey, 2021). This stereotype persists and even suggests that boys are better suited for mathematics while girls are better suited for the arts (Fleming et al., 2020).

Boys and Men are More Interested and Successful in STEM. Another common overall barrier and stereotype is that boys are more interested and successful in STEM than girls. More specific stereotypes can be broken down into the *brilliance* stereotype, gender-interest stereotypes, and expectancy. These specific stereotypes that may attribute to the gender gap in STEM classrooms will be discussed in the following subsections.

"Brilliance" Stereotype. One of the stereotypes in the STEM field is that men and boys have an innate *brilliance* in STEM disciplines, which can lead to a lower representation of women in STEM (Maries et al., 2022; Stewart-Williams & Halsey, 2021). This stereotype occurs because historically the individuals who have been recognized to have contributed to the STEM field were *brilliant* men. This pervasive stereotype trickles down through younger ages where girls do not believe they will be as successful in STEM because they are not as *brilliant* as boys (Maries et al., 2022). The *brilliance* stereotype is persistent starting with young children through college-aged individuals. Maries et al. (2022) explained that brilliance attributions highlighted in favor of men can cause women to be very hard on themselves and not have the levels of self-efficacy to believe they are capable of success in STEM.

Gender-Interest Stereotype. The stereotype of boys' interest and success in STEM also contributed to the interest-stereotype issue. The interest-stereotype issue is described as one group having a lower liking, enjoyment, or predisposition to succeed and engage in a particular topic than another group (Master et al., 2021). This stereotype suggests that the reason for the gap in STEM is that girls are by nature not as interested in STEM subjects as boys are. Master et al. (2021) completed a study on gender-interest and gender-ability, in which both boy and girl students reported that girls have significantly lower interest in pursuing STEM than boys. Master et al. (2021) explained that girls' reason was if their group is not interested, they are not likely to belong in the field which deters them from participation. These findings support Bem's gender schema theory regarding boys being socialized and normalized to find interest in certain subjects, such as STEM, and girls are socialized to enjoy different subject areas that are pinned as more feminine.

Expectancy. Within the stereotype of boys being more interested and successful in STEM, expectancy also plays a role. Expectancy is an individual's belief about success in a discipline (Maries et al., 2022). Expectancy is closely related to self-efficacy and women usually have lower self-efficacy/expectancy in STEM areas due to factors such as vicarious experiences, social persuasion, level of anxiety, and performance feedback (Maries et al., 2022). This stereotype of expectancy can cause dropout rates from STEM majors to increase in the girl population but not the boy population. In a study of GPAs between women and men in a STEM major, it was noted that on average, women were earning higher grades than men, yet more women dropped out of the major (Maries et al., 2022). This statistic shows that the stereotype that men are better than women in STEM is untrue, yet girls' levels of self-efficacy remain lower than boys. Maries et al. (2022) discerned that the reason for the dropout rates must be from another source such as a lack of belonging in the STEM environments. The next heading addresses the stereotype that STEM is a career in isolation.

STEM is a Career in Isolation. A common stereotype about STEM, in addition to its being “meant for men” is the fact that many individuals believe it is a career in isolation. To some, this may be enticing, but for most girls, it can drive them away. There have been studies conducted about the stereotypes that students form about scientists and engineers. So et al. (2022) found that students often form stereotypes about scientists’ appearance, social skills, and behaviors. So et al. surmised that students commonly view scientists as masculine and unattractive, working alone and indoors with limited social life, and earning a lot of money. When students were asked to draw pictures of scientists and engineers, they often drew men who were working alone in a lab or building things to solve problems (So et al., 2022).

The stereotype concept of working alone and in a masculine-dominated field is not as appealing to girls. The idea of a career in isolation drives girls away because they typically prefer working in small groups, which decreases girls’ participation and future interest in STEM (Wieselmann, Dare, et al., 2020). In addition, Stewart-Williams and Halsey (2021) explained that girls place more importance on work-life balance and spending time with family and friends. The stereotype of STEM being a time-consuming and demanding field steers girls away because it would make maintaining relationships with friends and family difficult while in the STEM occupation. On the other hand, boys and men tend to place higher importance on career success and income than the average woman, making the stereotypical, high-paying STEM field more appealing, even if they need to work in isolation (Stewart-Williams & Halsey, 2021). The next section will address the chilly climate as a barrier to girls and women in STEM.

Barrier 3: "Chilly Climate" in STEM

A chilly climate towards women in STEM is another barrier that they must face. A chilly climate refers to how traditionally masculine fields are unwelcoming or hostile toward women (Jensen & Deemer, 2019). A chilly climate does not only occur between boy and girl peers but can also come from teachers interacting with boy and girl students differently in the classroom (Miner et al., 2019). Oftentimes, the chilly climate comes from boy peers toward girls and has many negative impacts such as lacking a sense of belonging, disengagement, and lack of persistence in the field (Jensen & Deemer, 2019). According to Miner et al. (2019), there are two main indicators of a chilly climate in STEM, ostracism and incivility. Men ostracizing women in STEM often involves the women being ignored from conversation, information exclusion, and group exclusion, making this indicator of chilly climate more of a discrete issue, but still recognized by the women in the field (Miner et al., 2019). Incivility, on the other hand, is more of a direct threat to women, which is defined as rude, sexist, and discourteous behavior that lacks regard or respect for women in STEM (Biggs et al., 2018; Miner et al., 2019). Overall, a chilly climate can be harmful to the well-being and career trajectory of women in STEM due to consistent exposure to an unwelcoming and hostile environment (Jensen & Deemer, 2019; Miner et al., 2019).

To further investigate the impacts of chilly climate in STEM, Cyr et al. (2021) conducted a quantitative study to figure out why women are socially excluded in fields dominated by men. Some of their findings include the fact that men with implicit stereotypes report socializing with fewer teammates who are women, resulting in women reporting more negative workplace outcomes. On the other hand, Cyr et al. (2021) found that women benefit from experiencing cross-gender social inclusion and report greater workplace engagement, self-efficacy, and lower social identity threat. Within the realm of the chilly STEM climate, women can endure the negative impacts of sexism and gender bias. Oftentimes when women report a chilly climate, they also report acts of sexism and gender bias in the workplace or classroom setting, which will be addressed in the next subheading.

Sexism and Gender Bias in STEM. Negative outcomes of a chilly climate in STEM are sexism and gender bias. Research shows that sexism and gender bias continue to put women at a disadvantage in the STEM field such as having less start-up support in biomedical research than men and being less likely to be invited to STEM colloquiums, while men are more likely to receive tenure and be promoted to leadership positions in STEM (Biggs et al., 2018; Casad et al., 2021; Moss-Racusin et al., 2018). A study found that women at a STEM conference perceived a more sexist climate and exclusion than men did, making them feel as though their intellectual STEM abilities were not up to par with their masculine counterparts (Biggs et al., 2018). Sexism and gender bias become significant issues because even if the negative stereotypes about girls in STEM are not accurate, a culture of gender bias and sexism can create poor STEM outcomes for women. Fleming et al. (2020) explained that gender bias against women in STEM can affect self-esteem and performance in their field. Even when women in STEM have attempted to persevere through the gender bias and sexism they may endure, they find little reason to stay in the field long-term due to fear of continued discrimination or no sense of belonging in their place of work (Fleming et al., 2020).

In the classroom, girls are often affected by sexism and gender bias in STEM. Girls have reported being discouraged from participating in STEM subjects such as mathematics and science (Robnett & John, 2020). This negative connotation toward girls in STEM weakens girls' interest in STEM, makes them feel like they do not belong in STEM environments, and undermines their motivation (Kuchynka et al., 2018). Girls are not oblivious to these biases and sexist connotations, as they have reported hearing these negative comments from peers about their STEM abilities and feel that they need to work harder than boys to be taken seriously (Robnett & John, 2020). These various acts of sexism and gender bias in the classroom create negative feelings for girls in STEM. Since girls are well-aware of the negativity that can come from participating in the STEM field, they may be trying to avoid the field altogether in an effort to not become victims of gender bias and sexism in their future careers. The fourth barrier that women and girls face in STEM fields is family building and relationships while participating in the STEM field, which is addressed in the next section.

Barrier 4: Family Building and Relationships While in the STEM Field

Another barrier that women face in STEM is the angst of missing out on romantic and family relationships. A common thought about the STEM field is that it is extremely demanding, can have extended hours, and women in the STEM field do not commonly marry. Although the STEM field is challenging, research shows that most women in the STEM field do marry (Dunlap et al., 2019). This barrier remains an obstacle for women because there is a truth behind this perceived barrier, especially when regarding building a family. According to Luscombe (2019), almost half of the new mothers leave full-time STEM careers after either bearing or adopting a child. After having children, 71% of new mothers left the STEM field entirely for a new line of work (Luscombe, 2019). This statistic is also true for new fathers, as a quarter of fathers leave the full-time STEM field when they become a parent, but often return to work full-time when the child starts school (Luscombe, 2019). Although the difficulty of having family is present for mothers and fathers, it is more prevalent in mothers as statistics show they leave the STEM field more frequently than the men do. The data are not unknown, as girls know and hear about how STEM can be very time-consuming, making it difficult to maintain a work-life balance. Because many girls and women believe the STEM field is not attainable if they want a romantic relationship or family, they will choose to leave or never enter STEM majors and careers to instead focus on traditionally feminine roles in society (Dunlap et al., 2019).

The findings from Dunlap et al. (2019) supported Bem's gender schema theory relating to how women are socialized with the responsibility to take on a feminine role such as building a family and maintaining a household. Dunlap et al. (2019) found that women are driven away from STEM due to their yearning to get married and start a family. Luscombe's (2019) findings also supported the gender schema theory as a feminine role asserts that women should stay home with the children, and the masculine role would be to return to work and earn money for the family. In turn, there is an increase in the gender gap due to the STEM field being too demanding for women to maintain feminine roles and a STEM occupation concurrently. The next section explains how the barriers that were addressed in this section influence the perceptions of girls and teachers in the STEM classroom.

Barriers Related to Perceptions

The barriers that women face in STEM directly relate to the perceptions that they have of themselves as well as their teachers' perceptions. Teachers play an essential role in how students will approach future academic pursuits. George et al. (2020) found that teachers help students build their confidence about STEM and changed the way participants viewed their abilities in STEM. In turn, it is important to understand how girls view themselves in STEM and how teachers view girls in STEM so the gender gap can be investigated and lessened. In the next section, the important spheres of influence and their perceptions of girls in STEM will be addressed.

STEM Perceptions from Important Spheres of Influence

A sphere of influence is commonly used to refer to the influences that shape a young person's interests and aspirations (Campbell et al., 2020; Coenraad et al., 2021). Girls have spheres of influence that will shape their interest levels and aspirations for pursuing STEM. Some of these spheres include teachers, parents, and peers, in which all these spheres have their own beliefs and perceptions about girls in STEM. The perceptions and beliefs from these spheres can impact the way girls view themselves and pursue STEM through their academic experiences. The spheres that have a heavy impact on girls in STEM include their own self-perceptions and teacher perceptions. It is important to understand the perceptions and beliefs held by girls and teachers to understand why the gender gap exists in STEM and how to lessen it. Girls' self-perceptions in STEM, teachers' perceptions of girls in STEM, a counterargument of teachers' perceptions of STEM, and the need to shift perceptions of these spheres will be addressed in the headings below.

Girls' Self-Perceptions in STEM

The perceptions that girls have of themselves in STEM are not always positive. Oftentimes, girls lack confidence in their STEM abilities and are less likely to think they will end up working in the STEM field (Morrison, 2019). From a young age, girls believe they are not as brilliant as boys in STEM subjects (Maries et al., 2022). Even though girls lack a sense of ability in STEM, they outperform boys in math and science with 68% of girls getting top grades at 16 years old, compared to 65% of boys (Morrison, 2019). In addition, girls between the ages of 15 and 16 often tend to lose interest in STEM subjects while boys remain interested, even though research shows they still outperform boys (Trotman, 2017). This loss of interest could mean that girls' self-perceptions in STEM may not be developed internally, but their loss of interest is instilled in them from an extrinsic influence.

One of the major factors to consider about girls' STEM self-efficacy and self-perceptions is their exposure to STEM in a positive and engaging way. George et al. (2020) performed a mixed methods study to analyze if a STEM academy increased their self-efficacy. Students were questioned on their STEM self-efficacy pre- and post- academy and the findings revealed there was in increase in self-efficacy (George et al., 2020). Another study related to determining girls' self-perceptions in STEM was conducted by Ogle et al. (2017). The Fashion FUNdamentals program was intended to foster self-confidence and self-esteem for girls in STEM, as research showed that they were lacking. After girls working on STEM activities were engaged positively, interviews with participants later showed they felt more confident in STEM (Ogle et al., 2017). Overall, girls initially lack self-efficacy and have low self-perceptions in STEM subjects. Once girls are exposed to STEM in an engaging way, they become motivated and encouraged, and their self-perceptions start to increase.

Teacher Perceptions

Teachers play a significant role in the participation of girls in STEM. Starr and Simpkins (2021) explained that teachers are critical academic socializers for students. If a teacher holds a gendered belief about how girls should participate in STEM, it will heavily impact the students' beliefs and perceptions and will unknowingly model gendered responses to STEM (Campbell et al., 2020). Gendered beliefs even influence the way teachers assign roles in STEM projects or experiments. Yang and Gao (2021) sought to determine the impact of achievement motivation from the perspective of gender socialization. The study shows that teachers were more likely to impose gender stereotypes and gender socialization on girls rather than boys. Yang and Gao

(2021) found that teachers commonly assigned girls to record experiment results while the boys got more opportunities to participate in the experiments. These findings support the tenets of gender schema theory, which means that they assume roles in a certain way based on socialized gender perceptions. Ultimately, this was a gender-biased and gender-socialized STEM education model placed on students.

Teacher stereotypes and perceptions also have an impact on how students academically progress, as research has shown a relationship between a teacher's gendered STEM stereotypes with their likelihood to recommend a boy versus a girl student for math/science courses (Starr & Simpkins, 2021). In most cases, teachers are women and commonly may not associate themselves with STEM or can perpetuate their own math anxieties onto their students who are girls (Campbell et al., 2020). Because of this, teachers can send messages to girls about their lack of ability and interest in STEM due to their own preconceived notions of themselves (Campbell et al., 2020; Starr & Simpkins, 2021). This study also demonstrates alignment of the gender schema theory, as teachers in this case are the socializers and influence students to follow a masculine or feminine path based on their own perceptions of STEM.

Hand et al. (2017) explored how teachers and students held gender role biases that impacted the way that students pursue STEM. The findings of the study showed that both teachers and students held gendered beliefs that working in the sciences was a more masculine role and working in the humanities was a more feminine role (Hand et al., 2017). Teachers, who are key role models for students, can also have impacted behaviors towards students because of these gender biases. Hand et al. found that teachers can perceive boys and girls in mathematics differently, creating differential treatment such as encouragement, praise, or passing a student to the next academic level for boys over girls.

Counterargument. There are a variety of studies that revealed teacher perceptions do not hold gender bias and have supported girls in STEM. Timur et al. (2019) performed a quantitative study to analyze teachers' views on STEM teaching and investigated the difference between teachers who are men compared to women in relation to their interest in teaching STEM. The results found that both feminine and masculine-gendered teachers were eager to teach STEM and support girls in STEM. Teachers play a crucial role in determining students' interest in subjects, so if girls are encouraged by their teachers to pursue STEM, they will most likely follow that lead (Timur et al., 2019). Burns et al. (2019) explained that girls benefit from teacher support. In addition, Fredricks et al. (2018) found that girls reported feeling more engaged in STEM because they were supported by their teachers. To help girls feel accepted in STEM, support, and a sense of belonging need to be initiated by teachers and how they make students feel about participating in STEM.

Shifting Perceptions

Overall, strategies need to be put in place to completely shift the perspectives toward a more positive and welcoming outlook for girls in STEM. Teachers need to encourage girls and find new ways to shift their own negative thinking about their interests and abilities in STEM. These perspectives need to be changed so that girls can be better accommodated to increase interest and participation and furthermore excel in the STEM field. The next section will make connections and review studies on the informal teaching practices and strategies that have been put in place to engage girls and close the gender gap in STEM.

Informal Teaching Practices to Engage Girls and Closing the Gap in STEM

When considering the STEM gender gap, it is important to consider the perceptions of students and their struggles with STEM identity. Teachers need to be the driving force in helping girls stay motivated and engaged to continue pursuing STEM. Understanding and analyzing teachers' perceptions of the gender gap in STEM is essential so that the necessary strategies to increase interest, participation, and motivation can be implemented, which may attribute to lessening the gap. The strategy that teachers typically utilize to engage and increase interest is informal STEM learning experiences. A few ways that teachers can utilize informal engagement and motivation strategies for girls in STEM are introducing role models and mentors, early immersion, and intervention, adding the "A" for STEAM, training, and education on biases, inclusive and diversified instruction, and STEM experiences outside of school.

Role Models and Mentors

One of the major strategies that can be used to encourage girls and shift perspectives about girls in STEM is introducing role models and mentors who are women to girl students. Because women are underrepresented in STEM, the likelihood of having a STEM role model who is a woman is low, but it is important as to not threaten girls' interest and participation (Maries et al., 2022; Stoeger et al., 2019). Women who work in STEM fields or any STEM subjects are great candidates for being role models because they positively influence girls' interests and self-confidence (Stoeger et al., 2019). This positive influence could occur because girls feel comfortable confiding in other women and can relate to their experiences in educational and academic settings. González-Pérez et al. (2020) argued that girls being exposed to counter-stereotypical feminine role models in STEM help reduce gender stereotypes and increase girls' self-efficacy, and self-concept, as well as a high identification and commitment to STEM.

Early Immersion and Intervention

Immersing girls in STEM activities is another strategy to increase girls' participation in STEM. Research shows it is vital to pique girls' interest in STEM early on so that they can develop interest at an early age while getting involved in STEM before gender stereotypes develop (Blažev et al., 2019; Sullivan & Bers, 2019). Using resources such as toys, tools, and new technologies can be designed to be child-friendly and colorful with graphics that please the eye while also creating the foundations of computer programming in these young learners (Sullivan & Bers, 2019). Doing this is beneficial because it not only increases interest levels for girls, but immersion in these types of activities decreases stereotypes about scientists and other individuals working in STEM fields (Blažev et al., 2019).

Karalar et al. (2021) discussed the importance of early immersion and intervention for girls in STEM. The purpose of the study was to investigate the STEM attitudes of primary school students transitioning to middle school. The research shows that students typically have a high STEM attitude during their younger years, but when they transition into middle school, it tends to change for girls (Karalar et al., 2021). If there is no intervention or change to the curriculum during the transition into middle school, girls may continue with a low attitude towards STEM throughout the rest of their schooling (Karalar et al., 2021). Sullivan (2019) also explained that the best way to combat the development of negative stereotypes is to start early and reach kids while they are in their foundational years to combat gender stereotypes about STEM.

Adding the "A" for STEAM

Lastly, a way to engage girls and enhance their interest in STEM is by adding in an arts component to make it STEAM. According to Morrison (2019), only 32% of girls put a STEM subject down as their favorite, compared with 59% of boys. When it came to arts as their favorite subject, 32% of girls ranked that as their favorite compared to only 16% of boys (Morrison, 2019). Adding in arts can have a substantial impact on how girls find interest in STEM, especially at younger ages. Wajngurt and Sloan (2019) found that adding arts into STEM education helps to encourage girl students in early grades. Even including STEM later in 2-year and 4-year collegiate-level courses have a significant impact on girls' interest in STEM (Wajngurt & Sloan, 2019).

Training and Education on Biases

One of the ways teachers would be able to better support diversity in the STEM classroom is by reducing their own preconceived notions about gender and STEM. Teachers can support diversity through training and addressing implicit bias and stereotypes. Kollmayer et al. (2020) explained that teachers often lack strategies to counteract the unwanted gender stereotypes in their teaching, as this topic is rarely addressed or dealt with in regular teacher training. In fact, most interventions for stereotypes involve programs for students. The REFLECT program being designed for teachers would then be more sustainable and would reach more students because the root of addressing bias would start with the teacher and translate over to student learning. In addition to programs and professional development (PD), teachers can support diverse groups and girls in STEM by using inclusive teaching strategies.

Professional development in STEM implementation is also a method for improving instructional practice and engaging girls in STEM to close the gender gap. Affouneh et al. (2020) conducted a qualitative study to identify teachers' perceptions and attitudes toward STEM teaching based on their gender. Focus groups and semi-structured interviews were used to determine teachers' comfort level with teaching STEM. Affouneh et al.'s study findings revealed that teachers who were women and had negative attitudes were attributed to a lack of capacity, lack of self-efficacy, and insufficient skills to teach interdisciplinary subjects, but their perceptions changed after a PD program. Other teachers had positive attitudes because they saw the value in STEM education, especially after PD sessions. The qualitative study by Affouneh et al. is valuable because it supports the importance of teachers receiving training and PD on proper STEM instruction so that girls are encouraged and free of teacher-inflicted gender bias in the STEM classroom. In addition, the study by Affouneh et al. informs the study because the methodology, design, and qualitative data collection techniques prove to be an effective method for gathering teachers' perceptions in STEM teaching.

Inclusive and Diversified Instruction

A variety of strategies exist for engaging girls in STEM and helping teachers make their instruction inclusive and diversified for the needs of girls in STEM. According to Reinking and Martin (2018), teachers need to provide experiences and work with girls on staying engaged in STEM. Teachers can do their research on programs that help to increase interest and participation for girls in STEM that can be done in the classroom. Examples of these are Girls, Inc., Techbridge Girls, and STEM Next Opportunity Fund, which also help teachers understand how to better diversify their STEM instruction. Kinskey (2020) also explained that teachers can design their instruction to include examples of women in STEM to show diversity and inclusion in the field. Showing pictures of women in STEM fields who are modern women in STEM and STEM leaders cultivates confidence, interest, and motivation in STEM (Kinskey, 2020). Doing this also provides experiences for girls in STEM, makes the learning environment safe, and free of gender bias, and combats socialized gendered stereotypes (Reinking & Martin, 2018).

STEM Experiences Outside of School

Hug and Eyerman (2021) sought to determine the impact that informal learning outside of school had on girls' STEM engagement. Girls went to an afterschool camp called Techbridge Girls to support young women's engagement in STEM. The study shows that the implementation was effective in broadening girls' engagement in STEM, especially engineering design, and familiarizing youth with STEM career possibilities (Hug & Eyerman, 2021). One of the most significant findings of Hug and Eyerman include the influence that the afterschool program had on formal learning settings for girls in STEM. Teachers were able to recognize their students as "experts" in follow-up activities from the Techbridge Girls program brought into the classroom, which increased engagement and self-efficacy for girls in STEM (Hug & Eyerman, 2021).

Another informal learning opportunity is that teachers can help girls get involved in our STEM conferences and field trips for girls. Webb and Shores (2020) explained that engaging girls in this type of informal learning can help them build their STEM identity and start to see themselves as scientists, engineers, or in other STEM-related careers. For example, the Girls Rock STEM Conference was developed by a group of local schoolteachers to empower girls in STEM and immerse them in a variety of STEM experiences. Webb and Shores found that after the conference, 100% of the attendees said they would attend again, and all attendees gained an increased interest in forensics, robotics, chemistry, mathematics, and medicine. These statistics show that teachers can help put together informal learning strategies to help girls realize they are capable and accepted in the STEM field. The gap in the literature is addressed in the next section.

Gap in Literature

The review of literature portrayed the state of research on the gender gap in STEM, contributing factors to the STEM gender gap, teachers', and girls' perceptions of the gender gap in STEM, and strategies used to attempt to lessen the gap. Though a multitude of articles have been produced on the gender gap in STEM, a lack of research existed to show if teachers were adjusting their formal instructional practices to help lessen the gap. The research has noted the important role of teachers in encouraging their girl students to pursue STEM and increase their motivation (Timur et al., 2019). Further research is needed to explore the impacts on teachers' instructional strategies during formal class time to motivate and encourage girls in STEM. Many articles referenced the informal strategies to engage girls in STEM such as peer groups, introduction to role models, and camps (Reinking & Martin, 2018), but literature was lacking to show effective formal strategies that teachers are utilizing in the classroom to help lessen the STEM gender gap.

Furthermore, existing research commonly seeks to understand students' and teachers' perceptions of the barriers girls and women face in STEM fields, girl students' self-efficacy in STEM, as well as their interest levels. There were also various studies to collect data on teachers' and students' perceptions of perceived gender bias, sexism, and stereotypes toward girls in the STEM classroom (Hand et al., 2017; Moss-Racusin et al., 2018). Still, there are unanswered questions within the research as to how teachers utilize formal instruction to break down those barriers and meet the needs of girls to increase participation, interest, and engagement in STEM classes. King and Pringle (2019) conducted a study to evaluate how underrepresented girls used their informal STEM learning that took place in an outside program and translated it into their formal instruction during school, but the focus of the study was not on formal schooling and was still on informal STEM experiences. The lack of teacher perceptions continues to leave a gap in the literature on formal STEM learning experiences for girls. The research shows that girls face barriers in STEM and that girls are needed in STEM, but there is not enough research on instructional practices teachers can utilize during formal instruction to lessen the gender gap. The need for girls in STEM is covered in the next section.

The Need for Girls in STEM

On a national level, it is critical to increase girls' engagement in STEM. Currently, the United States suffers from a shortage of STEM workers, and if the country wants to maintain its superiority in science and technology, millions of STEM workers must be hired within the next decade (Zaza et al., 2019). Because women make up a lower percentage in the STEM field, increasing the number of women in STEM will boost the overall amount of STEM workers needed in the United States. Economically speaking, increasing numbers of girls and women in STEM helps to narrow the gender pay gap, enhances economic security for women, and diversifies the STEM field (AAUW, 2022). When fewer women are part of the STEM workforce, the country becomes less innovative essentially having worse long-run economic growth (Brenøe & Zölitz, 2020). Therefore, there are societal and economic long-term implications as to why girls are needed to be engaged in STEM starting at the middle and high school levels.

Chapter Summary

The research strategy and gender schema theory as the theoretical framework were reviewed in Chapter 2. Subsequent articles reviewed through Chapter 2 included recent and significant studies relevant to the influence that STEM teachers' perceptions and beliefs about girls in STEM and their strategies for lessening the gender gap. The topics specifically reviewed throughout the chapter included the history of girls and women in education and STEM, equitable education and STEM participation, the barriers that girls and women face in STEM, the perceptions of girls and teachers in STEM, and informal teaching practices to engage girls in STEM. A thorough examination and synthesis of various scholarly articles indicated a gap in the literature about the role of teachers in girls' STEM learning, stereotypes and gender bias relating to girls in STEM, and girls' formal STEM learning experiences (Hand et al., 2017; King & Pringle, 2019; Moss-Racusin et al., 2018; Timur et al., 2019). Most importantly, the problem of adapting formal classroom instruction to meet the needs of girls in STEM classrooms was not addressed. In Chapter 3, the research methodology, design, rationale, role of the researcher, research procedures, data analysis, reliability and validity, and ethical procedures will be addressed.

Chapter 3: Methodology

When it comes to student choice in the educational pipeline, many girls are choosing not to participate in STEM (STEM) courses. Specifically, within middle and high school grade levels, boy students are more likely to enroll in AP courses such as computer science, physics, and other STEM subjects (Sansone, 2019). The problem was there is a gender disparity in middle and high school STEM classrooms, in which teachers often lack an understanding of the underlying reasons and measures needed to lessen the gender gap. The gender gap in STEM was an issue because it continues through postsecondary schooling, where women are the minority in STEM majors and have a higher tendency to switch to non-STEM majors (Sansone, 2019). Ultimately, girls choosing not to participate in STEM courses leads to a lower girl population in the masculine-dominated STEM workforce. The purpose of the basic qualitative study was to explore central New Jersey middle and high STEM teachers' perceptions of the gender gap in STEM classrooms. This study helped to determine how middle and high school STEM teachers view the gender gap in STEM and strategies for engaging girls in STEM. Open-ended qualitative research questions were developed to understand STEM teachers' perceptions of the gender gap in their classrooms. The following research questions guided the study:

Research Question 1: What are teachers' perceptions about the gender gap in STEM education?

Research Question 2: What strategies do teachers use to address the gender gap and engage girls in STEM education?

Topics outlined include an introduction stating the problem, purpose of study, and research questions. The explanation of how this study will be conducted will appear throughout the headings under research methodology, design, and the role of the researcher. Additionally, the research procedures will cover the population and sample selection.

Research Methodology, Design, and Rationale

The purpose of the basic qualitative study was to explore central New Jersey middle and high school STEM teachers' perceptions of the gender gap in STEM classrooms. Determining the methodology and design was essential for the foundation of the study. The rationale to support the chosen methodology and design will be reviewed.

Methodology

A basic qualitative approach was the research methodology used in this study. The qualitative approach was the chosen methodology because the objective of this study was to see through the eyes of the participants and interact with subjects to gather their perceptions (Smith, 2021). Characteristics that deemed the qualitative methodology as more appropriate than a quantitative or mixed methods methodology were that the study does not aim to use standardized questionnaires or collect numeric data (Rutberg & Bouikidis, 2018). Instead, the goal of this study was to use multiple means of data collection to further understand the identified problem (Rutberg & Bouikidis, 2018).

Design

A basic qualitative design was chosen for this study because the characteristics and needs of the study do not fall into the commonly used methodologies such as phenomenology, grounded theory, ethnography, etcetera (Kahlke, 2014). Various aspects from each of the different methodologies were utilized to become a generic or basic qualitative study. Using a basic qualitative design was also appropriate for answering the research questions because it was intended to focus on how people interpret their experiences, and this study investigated the experiences of middle and high school STEM teachers (Kahlke, 2014). When the choice of a basic qualitative approach was in question, time and resource constraints were considered. The basic qualitative approach was deemed most appropriate because the context of the study met the readily available participants who best fit the research and were most knowledgeable, accessible, and available to answer promptly.

An advantage and potential benefit of choosing a basic qualitative design was that this type of research is typically conducted by someone who has pre-knowledge/pre-understanding of the topic (Percy et al., 2015). Being already versed in the topic of study was an advantage and a benefit because pre-knowledge before conducting research helps expand upon an already known subject while guiding further research to investigate information about participants' real-world opinions, ideas, or reflections (Percy et al., 2015). Ultimately, using a basic qualitative design helped to gain insight into teachers' perceptions of the gender gap in middle and high school STEM classrooms and how it can be addressed at the instructional level.

Role of the Researcher

My role as the researcher conducting this basic qualitative study was interviewer and analyst. I needed to make participants feel comfortable enough to report on their ideas about things that are actual events and issues that may impact them on a personal or professional level (Percy et al., 2015). Being the sole researcher in this study meant it was essential to disclose the personal and professional relationships to participants for complete transparency to future readers of the completed study. I have been teaching for 5 years at the research site. I have never had administrative responsibilities or any type of power over the participants within those 5 years. All the participants were colleagues who serve as equal counterparts, and no administrators participated.

It is important to note that because this research was about STEM teaching and related to my field of work, it lent itself to potential ethical issues such as doing a study in my work environment. Therefore, I ensured that data collection or interactions with participants occurred outside of contracted school hours to avoid associating responsibilities and duties at work with the study. In addition, there was also potential for different types of bias, such as selection/participant or analysis bias. For example, analysis bias means that a researcher may look for data confirming personal experiences or overlook data inconsistent with personal beliefs (Smith & Noble, 2014). Avoiding this type of personal bias is difficult, so I made sure to state my association with the study and participants at the beginning of the study. It was also essential to find concrete trends through coding so that my data were more dependable, and my interpretations held higher validity.

Research Procedures

Before any data collection occurs, researchers must make critical decisions for their study. Researchers must decide on the methods and strategies they will implement to gather the information needed to address the research questions. The research procedures will entail population and sample selection, instrumentation, instrumentation validation, and data collection.

Population and Sample Selection

A central New Jersey middle and high school district was the identified research site for this basic qualitative study. The target population will be 61 STEM teachers within the school district, and the sample size will be 23 STEM teachers who have been teaching for at least 3 years. The number chosen for the sample size was necessary to gather enough data to make sufficient conclusions and interpretations, whereas any sample size smaller than 15 may not provide enough data. The sampling method that was utilized is purposive sampling, also known as judgment sampling, to deliberately choose participants based on specific qualities related to the purpose of the study (Etikan et al., 2016). Teachers who had experience teaching science, technology, engineering, or mathematics subjects and have been teaching for at least 3 years were included in the study. If teachers have not been teaching for at least 3 years and did not teach any STEM-related subjects, they were excluded from participating in the study. Teachers were also excluded if they feel they may be biased toward the study and research questions or if they were not willing to sign informed consent.

Obtaining informed consent and demographic information was initiated through invitation letters of interest. These letters were sent via email to all possible participants asking for their participation, containing a description of the study and participant criteria (see Appendix A). Since the potential participants were all employed within the same district as the researcher, the researcher already had access to all emails needed for invitation emails to be sent effectively. The exact participants within the sample population were determined after the potential participants responded with their agreement or disagreement to participate in the study. Participants were informed that participation is entirely voluntary and can choose whether they prefer to be interviewed in person or over an online video conferencing platform at the participants' convenience. For participants to fully understand the details of the study and obtain eligibility to participate, informed consent needed to be signed and submitted to the researcher (see Appendix B). In addition, a requisition letter was sent via email to the acting superintendent of schools to approve the research site and interaction with participants (see Appendix C). The acting superintendent responded promptly with approval of site use for the research study (see Appendix D).

Questionnaires

A questionnaire was one of the data collection instruments utilized for this basic qualitative study (see Appendix E). The questions within the instrument were developed by the researcher for participants to answer questions in their own words instead of choosing from a set of predetermined answers (Albudaiwi, 2017). In this specific open-ended questionnaire, participants answered with “yes” or “no” and elaborated upon their answers. Following this approach allowed the researcher to take a holistic and comprehensive look at the gender gap in STEM classrooms from the perspective of STEM teachers (Albudaiwi, 2017). The research questions in this study were developed to gain a deeper understanding of STEM teachers’ perceptions of the gender gap in STEM classrooms. The interview questions aligned directly with the research questions to ensure that the researcher gathered relevant information for the study and better understood the population’s perceptions (Hahn, 2020).

Semi-Structured Interview

Semi-structured interviews were implemented as the second data collection instrument for the study (see Appendix F). In creating the interview questions, first, the overall topic of the STEM gender gap was considered. Next, the themes of the interview were deliberated to start formulating the research questions that would take place in the interview. Finally, the specific question stems that would guide the interview was fully developed and written out (McIntosh & Morse, 2015). The questions within the interview were primarily developed by reviewing the research questions and ensuring alignment so that the questions are valid and reliable. The semi-structured interview ascertained participants’ perspectives regarding the gender gap in STEM classrooms (McIntosh & Morse, 2015). Semi-structured interviews were the chosen method of data collection because a semi-structured interview approach allows for follow-up questioning that slightly diverges from the script so that the interviewer can gather additional open-ended responses from participants (McIntosh & Morse, 2015).

Subject Matter Experts

When creating original questionnaires and interviews that other research professionals did not previously develop, it was critical to seek item validation from subject matter experts (SME). SMEs were needed for this study to provide feedback on the validity, reliability, and alignment of the research questions to the questions within the questionnaire and semi-structured interview. The SMEs contacted included a school director of STEM curriculum, a middle school STEM teacher, and an upper elementary school STEM teacher. The SMEs provided feedback about the clarity of the questions, grammatical mistakes, alignment to research questions, their thoughts about the study, and suggestions for adding questions that may be beneficial for data collection (see Appendix G).

An original questionnaire and set of interview questions were developed because after reviewing the types of interviews and questionnaires on the gender gap in STEM, it was found that they were insufficient in addressing the current research topic. For this study, the questionnaire and interviews needed to be designed to accommodate a more specific population of STEM teachers in middle and high school grade levels. Using existing questionnaires and surveys was beneficial in developing the format and style of questions. From there, ensuring content validity meant aligning the structure and style of already created interview questions and questionnaires and ensuring that the items being made were directly related to the research questions. The SMEs were able to verify whether this process was successful or unsuccessful.

Data Collection

In this basic qualitative study, data collection techniques were utilized via questionnaires and semi-structured interviews. All participants were sent the Google Forms questionnaire via email to begin the data collection process. Google Forms was the chosen platform for conducting the questionnaire because all participants work in a school district that operates on Google Workspace for Education, and they are already familiar with Google Forms. Participants were given a deadline to be determined by the researcher informing participants when to submit the Google Forms questionnaire. All the participants' responses were collected and recorded through Google Forms and compiled for later data analysis. According to Wolber (2018), Google Forms can be used for various purposes ranging from a one-question form to long multiple-section surveys, all while eliminating the need to decipher and tally responses by hand. Google Forms also has functions for providing individual answers and a summary of responses to compare data.

The second form of data collection implemented in this study was semi-structured interviews. The semi-structured interviews took place after the questionnaire phase has concluded. For the semi-structured interviews, participants were given a choice to participate in person or over a video conferencing platform known as Zoom and Google Meets. If participants choose to interview in person, the discussions will occur onsite in a neutral classroom setting outside of regular contracted hours. All participants were invited to participate in the interview process and were given time slots to choose from to conduct the interview. The interviews were video, or audio recordings, depending on the type of interview the participant chose.

After the completion of both questionnaires and interview questions, contributors were debriefed and encouraged to ask questions they may have had about the study and their responses. Participants were reminded of the contact information if they had further questions or concerns. The audio and video recordings were sent to participants to review their responses. Once the debriefing was completed and participants properly exited the study, the data were prepared for analysis. The Google Forms responses were compiled and downloaded into a Microsoft Excel spreadsheet to prepare the data. The interview sessions were played back to prepare for transcription.

Data Analysis

Data analysis was organized and conducted through careful and thorough transcription of interviews and compilation of questionnaire responses. MAXQDA was the chosen statistical software that was used because it is compatible with Microsoft Excel, audio files, and video files, which were all essential to the data collection process. The audio and video recorded interviews were imported directly into MAXQDA software, where a transcription tool for accurate transcription and coding was utilized. In addition, the questionnaire and interview responses were imported to MAXQDA, which was used for both questionnaire analysis and coding. For the interview sessions, open coding occurred. During the open coding process, informants' responses were sifted through to organize similar words and phrases into thematic domains and codes (Williams & Moser, 2019).

An evidence-based model that guided data analysis was thematic analysis. Braun and Clarke (2006) developed a six-phase approach to thematic analysis that will be used in this study. This six-phase approach begins with phase one, which involved transcribing and familiarizing oneself with the data by re-reading and re-listening to questionnaires and interviews. Phases two and three consisted of generating initial codes through open coding and then collating the codes into overarching themes. In phase four, the themes were reviewed, and thematic connections were generated. In phase five, themes were defined and named but also needed to be revised and refined so that the themes were clear and relevant to the data. Finally, in phase six, a report was produced to communicate a coherent narrative and an in-depth explanation of the findings (Braun & Clarke, 2006). Following this six-phase approach to thematic analysis helped portray conclusions from data analysis intuitively and comprehensively.

Reliability and Validity

There are various strategies for establishing credibility, dependability, transferability, and trustworthiness in a study. One of the ways the researcher ensured validity was by gathering "rich" data. Coleman (2021) explained that rich data are collected through audio recording rather than researcher notes to analyze raw data. Triangulation also ensured validity and dependability because using two different data collection measurements allowed for the corroboration of findings and formulation of an overall interpretation (Coleman, 2021). The triangulation process substantiated findings across the different datasets to reduce the impact of potential biases (Mackieson et al., 2018).

Transparency regarding the aim of the study was a method of ensuring reliability. By providing detail and rationale of the research with participants, the study was more transparent for both the participants and potential readers, making the study reliable (Coleman, 2021). In addition, consistent measurements were ensured by utilizing the same interview questions and questionnaire with each participant. The interviews were conducted as semi-structured interviews, but the foundation of the initial questioning was identical for each participant to promote dependability. The questionnaire was distributed in the same manner with the same questions sent to each participant, further fostering dependability and reliability.

Establishing trustworthiness in a research study is crucial. Reflexivity was the primary method to reduce bias and increase credibility. Reflexivity refers to the researcher's awareness of their influence on a study, how the study affects them, and their reflection on data collection and analysis (Mackieson et al., 2018). Implementing reflexivity means that the researcher must be explicit and discuss the meanings they associate with and social interactions that resonate with their relation to the study topic (Mackieson et al., 2018). To maintain reflexivity, the grounds for the rigor and trustworthiness of the study were disclosed and communicated (Mackieson et al., 2018). Finally, the study was dependable due to audio recordings and complete transcriptions of interviews, making the study trustworthy, reliable, and repeatable for researchers to continue studying this topic (Coleman, 2021).

Ethical Procedures

Ethical procedures are essential in any type of research that involves human participants. All details and intentions of the study were exposed to the participants, so they were fully aware of the study. Once the participants understood the study's intent, the participants were required to sign informed consent (see Appendix B), which was distributed once there was a notification of agreement to participate in the study. Participants were also encouraged to ask questions or request meetings if any further clarifying questions about the study were needed. All participants throughout the study remained anonymous by administering questioning via Google Forms without collecting participants' names, emails, or contact information. In addition, participants' names were not exposed from the interview portion of the study.

The Belmont Report plays a vital role in the consideration of ethical procedures. The three principles of the Belmont Report, including respect for persons, beneficence, and justice, were followed during this study because the study involves human subjects (Friesen et al., 2017). Respect for persons was ensured by allowing the participants to have their own opinions and judgments without obstruction. This research was also completely voluntary, with the purpose of the study being fully disclosed to participants before their participation, ensuring respect for persons. Beneficence was confirmed by ensuring no harm to participants and maximizing benefits. This study benefited participants because they can use the study's findings and their experiences to improve their instructional strategies. This study also followed the justice of the Belmont report because the participants were not a vulnerable group; instead, they were a connection to the problem being researched.

Another component of ethical considerations is the Institutional Review Board (IRB). The IRB is a committee that oversees and monitors research involving human subjects to ensure that subjects are treated ethically (Dziak, 2020). When conducting a study that involves human subjects, acceptance from the IRB must be passed. Other letters, such as a requisition letter for permission to use the research site, letters of interest to participate, and informed consent, were sent as a protocol for ethical procedures.

Ethical issues may also arise when the study involves participants associated with the researcher. Some participants may not feel comfortable sharing information with a colleague or may fear that information could be leaked to other colleagues outside of the study. To negate these ethical concerns, all information and data gathered from the study were secured in digital files that are password protected. Furthermore, when a study is conducted in the workplace, authority differentials may also be a concern. These concerns are voided since the participants and the researcher have the same workplace status.

To further protect participants, the lead researcher was the only person who had access to the data collected during the study. The Google account that was utilized for collecting and storing data requires two-factor authentication to ensure protection from data hacking/hijacking. To access data on the researcher's personal Google account, a personal device was used so there was no risk of data becoming accessible from a public or workplace device. All data were protected and preserved because data are stored on password-protected devices and accounts, including when data are imported from Google Forms to a spreadsheet. In addition, all participants' names and email accounts were erased from the interviews and questionnaires so that information cannot be traced back to those individuals. To protect the identity of contributors, each person was assigned a number so that their name cannot be traced back, and only their assigned number served as their individuality. When the study is complete, the data were destroyed by deleting the original Google Form data, all audio and video recordings, and any transcriptions and raw data. The information from this study will need to be retained for a minimum of 3 years. Following the 3-year retention time, the data will be destroyed for further protection of participant confidentiality.

Chapter Summary

The purpose of the basic qualitative study was to explore central New Jersey middle and high school STEM teachers’ perceptions of the gender gap in STEM classrooms. For this portion of the study, the population and sample size was identified, which is 23 STEM teachers who have been teaching for at least 3 years. After the site was approved, participants were recruited, and informed consent was signed, the data collection instruments were distributed to participants. It was determined by the researcher and SMEs that questionnaires and semi-structured interviews were most appropriate for conducting the study. After the data were collected, data analysis took place through a six-phased thematic analysis to decipher themes and findings from the data. In addition, reliability, validity, and ethical procedures were considered and adhered to during this study. Next, the goal of Chapter 4 will be to present the finding and results from the data analysis.

Chapter 4: Research Findings and Data Analysis Results

The aim of this basic qualitative study was to gain a deeper understanding of the gender gap in STEM education, especially in middle and high school classrooms. García-Holgado and García-Peñalvo (2022) explained that increased gender diversity in STEM may lead to more effective problem-solving and better outcomes for real-world problems, yet women and girls continue to be underrepresented in STEM areas. The problem was there is a gender disparity in middle and high school STEM classrooms, in which teachers often lack an understanding of the underlying reasons and measures needed to lessen the gender gap. The purpose of the basic qualitative study was to explore central New Jersey middle and high school teachers' perceptions of the gender gap in STEM classrooms to determine possible means of lessening the gap. The process for data collection, data analysis, results, reliability, and validity, and the chapter summary will be addressed. The following research questions will guide the study:

Research Question 1: What are teachers' perceptions about the gender gap in STEM education?

Research Question 2: What strategies do teachers use to address the gender gap and engage girls in STEM education?

Data Collection

Data were collected from a middle and high school district in the northeastern United States. All middle and high school STEM area teachers who have been teaching for at least 3 years were eligible for study participation. From that pool of eligible participants, an invitation to participate was sent out (see Appendix A). The invitation included a brief description of the study and an explanation of how participation is completely voluntary. To make the process more convenient for participants, that same invitation email contained the informed consent letter (see Appendix B). Including the informed consent letter along with the invitation to participate was intentional, so participants could further determine if they would like to participate and reduce the steps they would need to take in responding to the researcher. Participants uploaded the signed informed consent to a password-secured and multi-factor authenticated Google Form account. From there, the researcher had access to all 23 signed informed consent letters.

The timeframe for data collection was 51 business days. This 51-day timeframe included an invitation, uploading informed consent, and multiple steps of data collection. After the initial invitation letter was sent, a reminder was sent to all potential participants to provide the intent of study participation. Eight business days later, another reminder email was sent informing participants that they only have a few days remaining to volunteer for the study. In total, the timeframe for participants to decide if they wanted to participate was two weeks. Once the 23 participants were informed of their participation status, the questionnaire portion of the study was disseminated (see Appendix E). The participants were given another two weeks to complete the questionnaire. A reminder email was sent nine business days after the initial send-out. One day before the deadline, another reminder was sent to ensure that all participants submitted their responses. The questionnaire was completed virtually through a Google Form at the time most convenient for the participants, taking them about 10-15 minutes to completion rate. All participants were required one response to the questionnaire and completed the questionnaire by the requested deadline.

Within the 51-business day timeframe, interviews were also conducted (see Appendix F). 15 business days were allotted for participants to request interview times and dates. Prior to the interviews starting, participants had four business days to contact the researcher for their preferred date and time slot. The next day, a reminder email was sent to continue signing up for interviews. Two business days later, the interviews began, in which they were conducted at times of each participant's choosing. The locations of these interviews were dependent on the participants' preference, being in-person, via Zoom, or via Google Meets. Each participant was interviewed one time within a 10–40-minute time frame, depending on the conversations that occurred within the semi-structured interview. The deviation from the data collection plan proposed in chapter 3 was the sample population. The original aim for the sample population was 15 participants. After the invitation to participate was sent out to 61 STEM teachers, 23 offered to volunteer their participation in the study. Therefore, the 23 who opted to participate were included.

Data Analysis and Results

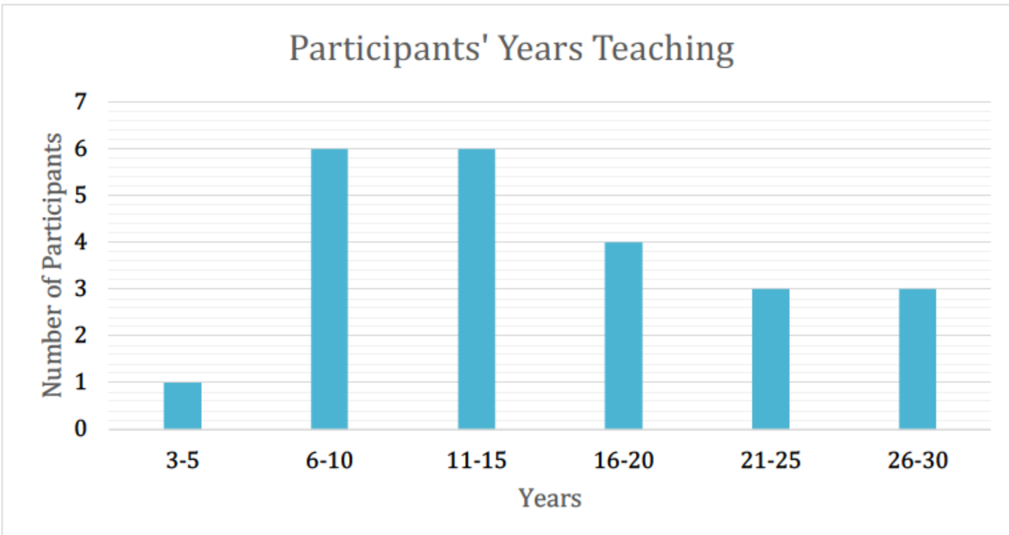
The data analysis and results section will address the demographic data of participants who responded to the open-ended questionnaires and interviews within the study. Thematic data analysis will then be discussed as the model used to gather information and answer the two research questions about middle and high school teachers' perceptions of the gender gap in STEM education. Findings related to the research questions will also be addressed.

Participant Demographics

Volunteers who participated in the study were first required to provide demographic information to shed light on their backgrounds without revealing identifying information. One of the pieces of information that participants disclosed was how many years they have been teaching. The invitation to participate required that participants have been teaching for at least 3 years. All participants have teaching experience anywhere between five and 30 years. For displaying this data, the number of years were grouped into increments of five. Figure 1 shows the range of years each participant has with classroom teaching experience.

Figure 1

Participants' Years Teaching

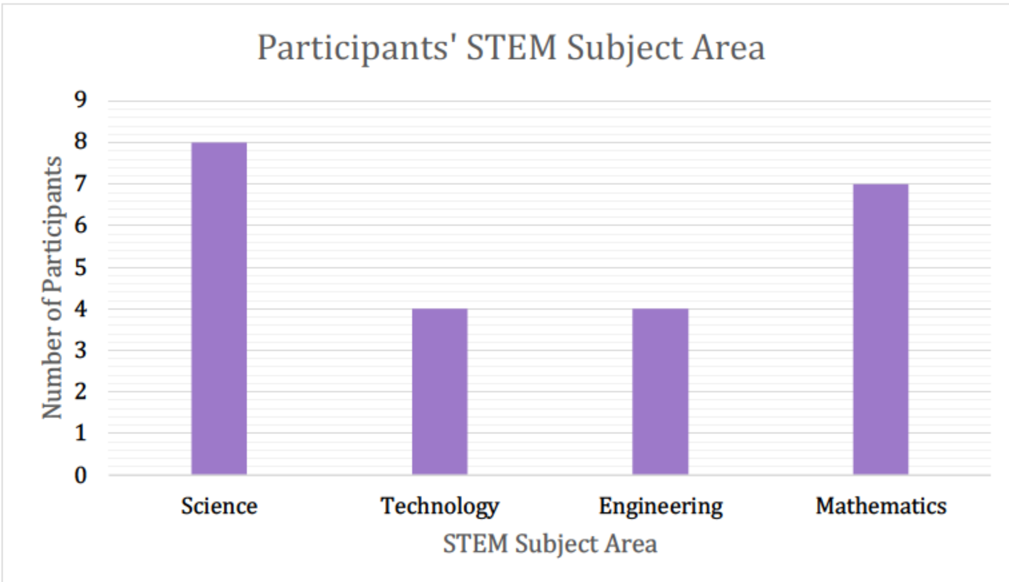


Note. The data for the amount of years taught were collected during the interviewing phase of data collection.

The next demographic piece of data that was collected from participants was the STEM area. STEM includes STEM, so data were gathered to see how many participants are involved in each of those areas. Figure 2 represents the number of volunteers in the study that teach within each subject area.

Figure 2

Participants' STEM Subject Area

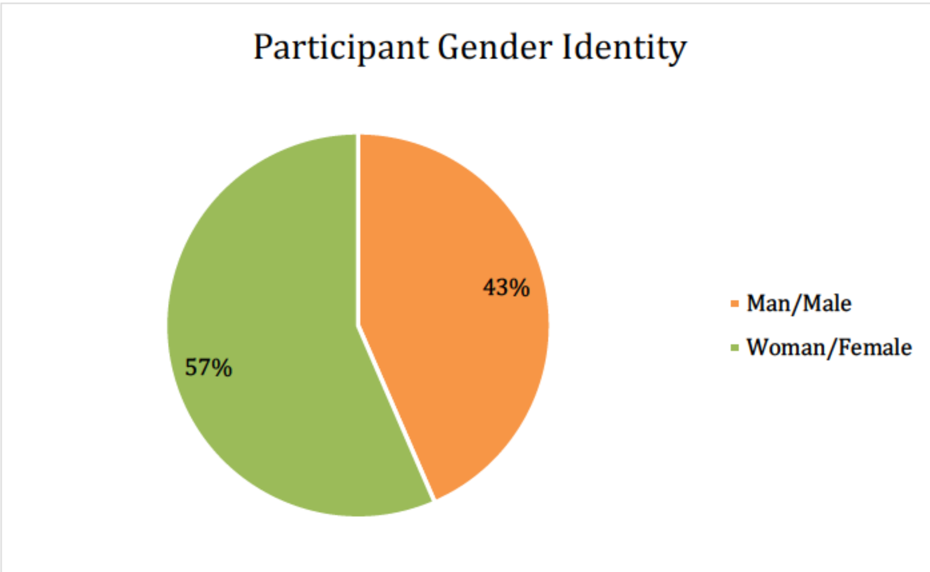


Note. The participants' subject area data were collected during the questionnaire phase of data collection.

Information on participants' gender identity was also collected as demographic information shown in Figure 3. Since the study is about the gender gap in STEM, gender identity was collected to analyze the different genders that participated in the study. Including gender identity is also important because it cannot be assumed that no differences exist between gendered groups (Hammer, 2011). Therefore, participants' gender was collected to understand ensure that various angles of participants' backgrounds are considered.

Figure 3

Participants' Gender Identity

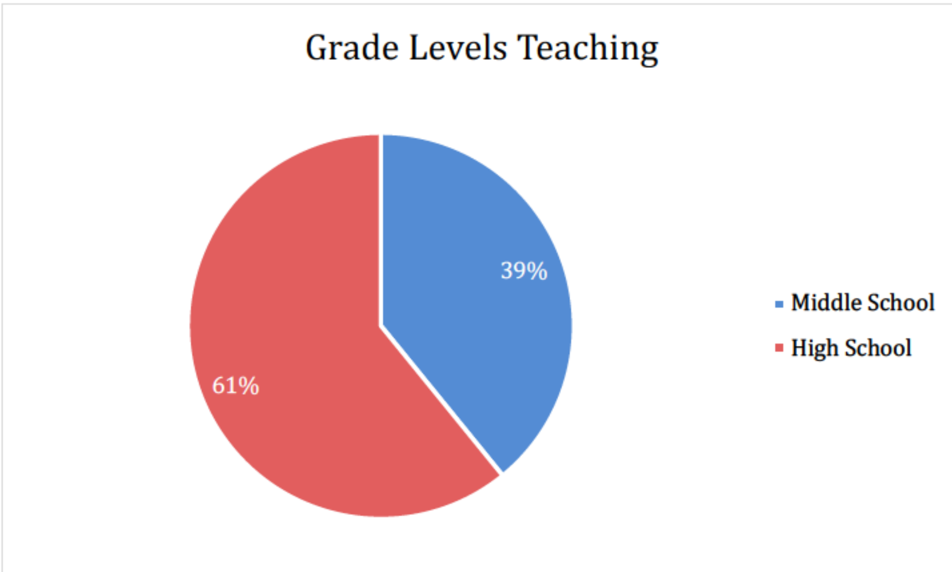


Note. The gender identity data were collected during the interviewing phase of data collection.

The last piece of participants' demographic data collected was grade level. This study gathered data from participants at both the middle and high school levels. To understand which school most of the information was being collected from, participants disclosed which levels they teach. Figure 4 represents the percentage of middle and high school teachers who participated in the study.

Figure 4

Participants' Grade Levels Teaching



Note. The grade-level data were collected during the interviewing phase of data collection.

Thematic Analysis

The data analysis model utilized for this study was thematic analysis. Thematic analysis was the chosen method of data analysis because it involves searching across a data set including large numbers of qualitative data, such as interviews and questionnaires, to find repeated patterns and trends (Braun & Clarke, 2006). The first step in the thematic analysis is familiarizing oneself with the data. Familiarization included re-reading questionnaire responses, re-listening to interview sessions that were recorded with consent, and transcribing the interviews (Braun & Clarke, 2006). After the data were thoroughly read and prepared for coding, the interview transcripts and questionnaire responses were imported into MAXQDA. MAXQDA was the chosen coding software because it allows for imports of various file types, offers transcription services, and has an intuitive coding system, making the coding process seamless between the two data instruments used in the study (VERBI Software, 2021).

After all data from both the open-ended questionnaires and interviews were imported and stored within MAXQDA, the next step of the thematic analysis was to generate initial emergent codes using open coding. Open coding was achieved by sifting through participants' responses and attaching codes to the segments of words, helping to organize similar words and phrases (Williams & Moser, 2019). The emergent codes were written as short paraphrases or summaries of the participants’ responses that were related to answering the research questions. The intention was to then revisit those codes later for step three of thematic analysis to search for potential themes (Braun & Clarke, 2006). The next step covered in the thematic analysis was reviewing themes and checking if the themes identified relate to the codes extracted from the raw data. To do this, the code was organized into sets so all similar codes could be grouped and analyzed to check for trends in the data. Next, the themes were defined and named, giving the overall analysis clear definitions and findings that were gathered from the data set (Braun & Clarke, 2006). Finally, the final step of thematic analysis was producing a report, in which concrete examples of the coded data set and themes. This included creating a table of all emergent codes, collapsed codes, themes, and direct quotes from the data set. Table 1 represents the overall codes and findings during thematic analysis for both research questions. There were six overall themes. The final themes were confidence levels, stereotypes, maturity and motivation, external influences, building comfort and confidence, and female role models and representation.

Table 1

Emergent Codes and Associated Themes

Emergent Codes	Collapsed Coding	Final Themes	Relevant Quotes
Girls are more interested in design and arts as opposed to STEM. Boys have more interest in STEM subjects and hands-on activities. Lack of knowledge in content within certain STEM courses. Girls don't prioritize STEM over other course-types Boys pursue STEM after middle and high school more than girls.	STEM is more male-oriented. Importance of increasing knowledge of STEM coursework to girls. Stereotypes cause boys to pursue STEM over girls.	Stereotypes and knowledge about STEM courses	"And I don't know if it's more moving parts or the stereotype of boys just want to mix things up and create and get dirty and hands-on stuff or not." "What I've noticed is that boys tend to attract more towards technology-based discussions and more like problem-solving. And girls tend to go more towards the creative side of everything." "When you see something in the course catalog, a STEM class, I'm sure a lot of the female students say there's probably going to be a lot of guys in the class or it's just not going to be my fit. And they don't even give it a try."
Girls feel more comfortable when girl peers are in their classes. Girls feel less comfortable in STEM classes where they don't have high girl populations. Parents can play a negative role in girls' STEM participation. Girls feel pressure to follow societal norms.	Girl peers have a major influence on engagement and comfort in STEM. Societal norms steer girls away from STEM. Parents and roles at home play a role in STEM participation	External influence on girls in STEM	"Maybe those female students will go tell other students how inspired they are to maybe get other females to take the class. It makes it more relatable when you do stuff like that." "When girls have friends in class or like other peers in class, maybe it helps support them like being more comfortable." "I think a lot of the cultural background and their social backgrounds, have a big impact on that. Like, you know, does the family consider

			science a big deal or is this just like, you know, a grade just a move on and keep going that I would think.” “I think a struggle are parents who are stuck of the mindset that it's okay if their daughter is not as great as science”
Girls take a backseat in STEM activities Boys are more outspoken in STEM classes Girls avoid risk-taking in STEM Girls are more hesitant due to fear of failure	Avoidance of risk-taking and failure in STEM. Higher male participation and confidence in STEM. Passive girls in STEM classrooms.	Confidence levels of boys and girls in STEM	“But it's tough when the boys have so much confidence and they're loud and very free to speak their minds, and the girls are not as confident, so they're like, maybe I don't belong here.” “And girls are more like they don't want to take the chance of doing something wrong and anyone making fun of them and all that.”
Girls are more organized in STEM courses Girls are more motivated than boys in STEM. Boys tend to be immature in STEM courses. Girls tend to be mature in STEM courses. Girls seem to be more attentive to detail.	Maturity differences between girls and boys in STEM classes. Girls are more motivated in the STEM classroom	Maturity and motivation in STEM classes	“I find girls are more focused and motivated most of the time.” “I noticed that in general, the females are way more focused way more studious.” “But since there are so many boys, they're all kind of showing off for each other, goofing off, they’re not taking the class very seriously.”
Help girls feel equal in STEM. Help girls accept failures. Highlighting girls’ accomplishments in STEM classes.	Breaking stereotypes for girls in STEM. Encouragement helps girls to pursue STEM.	Building comfort and confidence in STEM	“They think that they can't do it. And when they get pushed a little bit, they start realizing they can do it well.” “I've repeatedly encouraged them to voice themselves and point out when they know

Reassurance for girls in STEM. Intentional grouping strategies during collaborative work.	Intentional grouping in STEM to increase comfort levels		what they're doing and talk to other kids and say that kids a leader. You should follow her, so that by the time we get to the chemistry they're like, ‘Oh I'm good at this.” “So, I mean if that's one of the strategies I use is just making sure that the girls feel equal and if they are performing well to show that they're dominant in the classroom as well” “I try putting them into a comfortable place. I use a lot of humor, like making a mistake, or saying something's wrong. It's okay, right? Just trying to normalize making mistakes.”
Making STEM relatable to girls by showing inclusive multimedia. Female guest speakers and field trips for girls in STEM. Adjusting lessons to make sure girls also feel connected to STEM content. Calling on girls and boys equally in STEM classes.	Significance of female role models. Representing women and girls in STEM. Providing opportunities for girls to participate in STEM.	Role models and representation of women in STEM	“Classroom decor includes many women in science posters, I speak about my daughters pursuing stem careers, I encourage girls to take on leadership roles in labs. My main goal is to provide a positive and safe environment where the girls can feel safe to make mistakes as well as a place to celebrate accomplishments” “I've tried to find resources that highlight female scientists. For example, a video where a female is the lead scientist or the one disseminating scientific knowledge or images that depict women in science. I've learned that representation matters, and I want females to see other females in science.”

	"I provide opportunities by exposing girls in STEM classes and special programs such as Lockheed/Martin and Princeton."

Note. questionnaire and interview responses were coded and included in the data analysis table.

Findings for Research Question 1

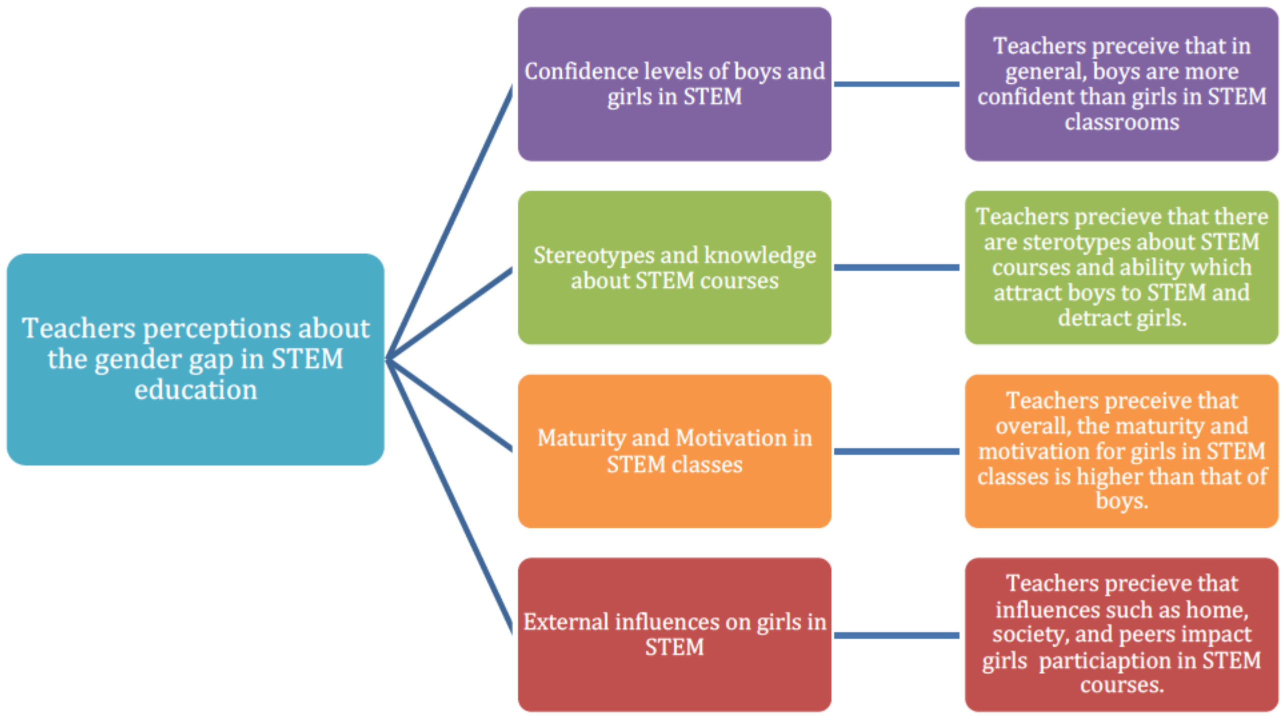
Research Question 1 (RQ1) asked, "What are teachers' perceptions about the gender gap in STEM education?" Through coding and data analysis, the themes including confidence levels of boys and girls in STEM, stereotypes and knowledge about STEM Courses, maturity and motivation in STEM classes, and external influences on girls in STEM closely align with RQ1. The theme regarding confidence levels of boys and girls in STEM emerged mostly during the interview sessions when asked, "What do you think may be part of the reason for any gender differences in your classroom?" Many participants expressed that boys are more willing to answer questions and participate in STEM classes compared to girls. In addition to the research question on perceptions of gender differences, another theme surfaced as many participants discussed their perceptions of the difference between boys' and girls' motivation and maturity in STEM courses. Teachers agree that boys have more confidence and comfort in STEM classes, yet girls are typically more mature and motivated to perform well. One participant stated, "But it's tough when the boys have so much confidence and they're loud and very free to speak their minds, and the girls are not as confident, so they're like, maybe I don't belong here." Teachers commonly explained that the difference in confidence levels and maturity in class impacts girls' initiative to take risks due to fear of failure in STEM classes.

Two additional themes emerged when asked during the interview, "What challenges do you face when implementing STEM and engaging girls in STEM?" The first theme that emerged as a challenging perception is the stereotypes around STEM and the knowledge of STEM courses available. Teachers agreed that there are stereotypes that some STEM courses seem like they are more geared toward boy students. One participant stated, “When you see something in the course catalog, a STEM class, I'm sure a lot of the female students say there's probably going to be a lot of guys in the class or it's just not going to be my fit. And they don't even give it a try.” So, teachers perceive that girl students are not entering STEM courses because they hold stereotypes about the courses themselves. In addition, teachers perceive that a challenge itself is the stereotype around STEM. Teachers explained that typically boys gravitate towards more technology-based discussions, while girls are typically more interested in arts and the creative side of assignments.

The last theme that emerged related to RQ1 is the external influences on girls in STEM including peers, home, and society. This theme emerged predominantly when teachers were asked about the challenges they face when engaging girls in STEM. Teachers agreed that home life and parental influence make a big impression on what girls’ interests are, what they believe to be good at, and what academic paths they wish to pursue as they go through middle and high school. On the other hand, the perception of teachers is that peers can have a positive influence on girls in STEM. One participant stated, “Maybe those female students will go tell other students how inspired they are to maybe get other females to take the class. It makes it more relatable when you do stuff like that.” In this case, the theme that emerged about external influences had both positive and negative perceptions from teachers. Figure 5 demonstrates the connection between the research question, four emerged themes, and specific code examples from participant questionnaires and interview responses.

Figure 5

Findings and Themes from RQ1



Findings for Research Question 2

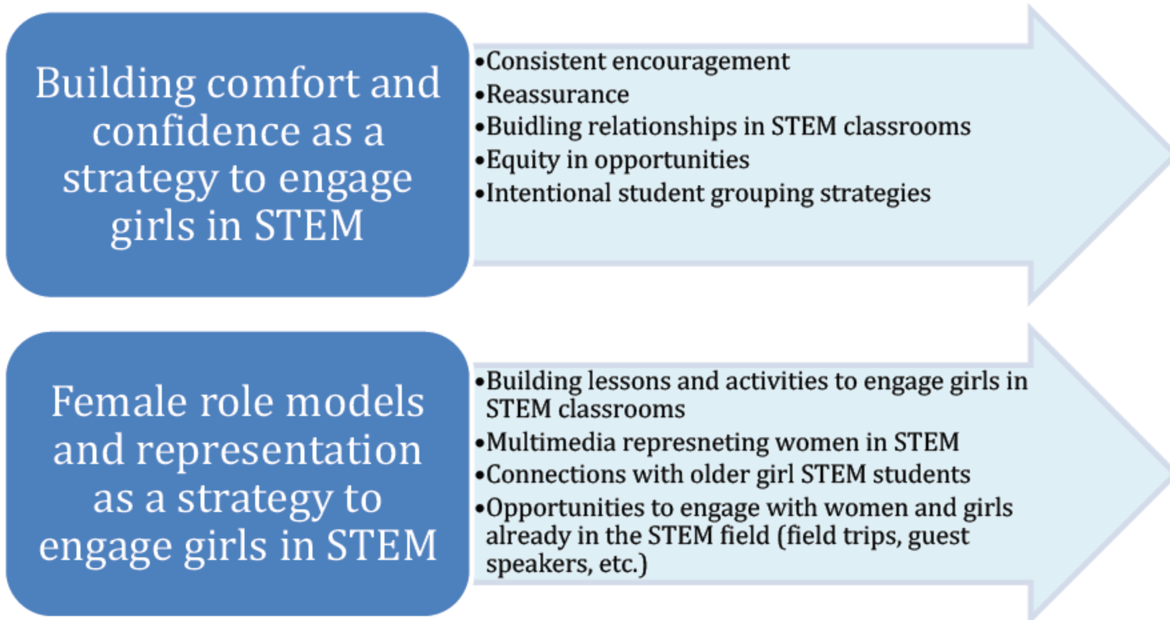
Research Question 2 (RQ2) asked, "What strategies do teachers use to address the gender gap and engage girls in STEM education?" This research question was answered and aligned with two prominent themes. The first theme that emerged regarding this research question was building comfort and confidence for girls in STEM. All teachers explained that one of the strategies they use to help girls in STEM is reassurance and encouragement. Teachers mentioned that most of the time, girls are hesitant to take risks for fear of getting made fun of or not being perfect. One teacher stated, "Girls want to be perfect all the time and STEM is about constant failure. You're going to fail all the time like that's it. If you're not failing, you're not learning.

And I think that's really hard for a lot of girls to do, is fail. They want everything to be perfect." To help with this issue, teachers have explained that they try their best to provide equal opportunities for leadership roles in class, build relationships between students in class, and group intentionally to make all feel comfortable in STEM classes.

A second theme that emerged from RQ2 is utilizing female role models and representation as a strategy to engage girls in STEM. Teachers agreed that using multimedia such as videos, pictures, and posters in the classroom is a strategy that they use to help build representation for girls in STEM. Teachers also mentioned that opportunities for girls to learn about female role models and professionals in the STEM field are a great strategy for building girls' engagement in STEM. A participant explained, "I discuss different STEM careers and use females as examples and role models." Teachers discerned that representing women in STEM inside of the classroom and exposing girls to female role models in STEM are efficient strategies to engage girls in STEM, which is the second theme aligned with RQ2. Figure 6 represents the details of the two themes that emerged from RQ2 regarding strategies teachers use to address the gender gap and engage girls in STEM.

Figure 6

Findings and Themes from RQ2



Overall, key themes emerged from the collected data through careful and detailed thematic analysis. The coded data and collapsed coding process exposed the trends within teachers' perceptions on the gender gap in STEM education. The research questions were answered through consideration of all participants' responses in the questionnaire and interview process. Table 2 represents a summary of the themes that were developed during data analysis.

Table 2

Research Question Theme Alignment

RQ1	RQ2
Confidence levels	Building comfort and confidence
Stereotypes	Female role models and representation
Maturity and motivation	
External influences	

Reliability and Validity

When considering qualitative research, there are common potential threats to reliability and validity that must be addressed. Some of these threats have been addressed in chapter 3, however, it is important to discuss the success with which those threats to reliability have been eliminated or controlled throughout the research process. According to Thurmond (2001), triangulation can be used as a method to increase the validity, strength, and interpretative potential of a study, while also decreasing researcher bias and providing multiple perspectives. In the current study, triangulation was implemented by utilizing a variety of data collection instruments in different phases of data collection, which is known as data sources triangulation (Thurmond, 2001). Credibility and dependability were also heightened due to the utilization of triangulation because triangulation increases confidence in research data, creates various ways to understand a phenomenon, and provides a clearer understanding of the problem (Thurmond, 2001). Consistency was also achieved through triangulation as a method of increasing dependability in the study. According to Brown (2017), enhancing or confirming dependability and consistency in the study can be achieved through method triangulation, time triangulation, and investigator triangulation. This study emphasized both method and time triangulation by incorporating multiple data collection tools and by gathering data multiple times (Brown, 2017).

In addition, reflexivity was initiated to promote credibility and dependability. To ensure reflexivity, the researcher needed to be able to step back and take a critical look at their own role in the research process to increase the quality and validity of the research (Guillemin & Gillam, 2004). Investigators need to be hyperaware of the potential factors that can influence the knowledge constructed during a qualitative study (Guillemin & Gillam, 2004). Critical reflection took place throughout the entire research process, including the data collection, familiarization with data, coding, and creating themes. During these steps in the research process, it was vital that the researcher was reflexive to increase reliability and validity.

Transferability was also implemented to promote reliability and validity in the study. According to Korstjens and Moser (2018), a researcher's responsibility when applying transferability is to provide a thick description of the participants and the research process, which would allow a reader to assess if the findings are transferable to their own setting. The thick description was achieved by explanation and figures representing the demographics of participants. A thick description of the research process was implemented by providing tables and figures describing coded themes from participant data as well as direct quotes and codes from thematic analysis. Participant selection and the process behind recruiting participants were explicitly explained, which also increases transferability in this study. Along with transferability, saturation plays a role in the validity of the qualitative study. According to Fusch and Ness (2015), data saturation is reached when there is enough information to replicate a study, and when further coding is no longer necessary. If data saturation is not reached, the threat to the validity of one's research increases (Fusch & Ness, 2015). Data saturation was achieved by conducting the interviews by asking multiple participants the same questions so that consistent data were collected and all possible data from those questions were coded. The data were saturated after the 16th participant, as no new codes emerged from the data. At that point, the same existing open codes were used for the remainder of the participants.

Trustworthiness within this study was achieved by reducing as much bias as possible. In any research study, bias is a threat to trustworthiness, but some strategies can be implemented to avoid such issues. One type of bias that had a potential threat to the trustworthiness of the study was selection bias. According to Pannucci and Wilkins (2010), a method to avoid and eliminate this type of bias would be through using a selection process for participants who has rigorous criteria and the population is clearly defined. Throughout the selection process, participants were required to disclose pertinent demographic information, and were excluded from the study if they did not meet the criteria to ensure avoidance of selection bias.

Chapter Summary

This basic qualitative study explored teachers' perceptions of the gender gap in middle and high school STEM education. The data collected from 23 open-ended questionnaires and semi-structured interviews helped compile information on teachers' perceptions. From there, MAXQDA coding software enabled codes and trends to be identified, which aligned participant data with overall themes from the research questions. RQ1 revealed four themes about teachers' perceptions of the gender gap in STEM. The themes were confidence levels of boys and girls in STEM, stereotypes and knowledge about STEM courses, maturity and motivation in STEM classes, and external influences on girls in STEM. RQ2 revealed two themes about strategies to address the gender gap and engage girls in STEM. The themes were building comfort and confidence in STEM, and female role models and representation in STEM classes to engage girls. For both research questions 1 and 2, figures and tables were utilized to visually represent the data collected and analyzed throughout the research process. In addition, strategies such as triangulation, consistency, reflexivity, transferability with thick description, and trustworthiness with bias reduction were all implemented to enhance reliability and validity. Next, the goal of chapter 5 will be to interpret the data findings from the research and draw conclusions based on the results.

Chapter 5: Discussion and Conclusions

The purpose of this basic qualitative study was to explore central New Jersey middle and high school teachers' perceptions of the gender gap in STEM classrooms to determine possible means of lessening the gap. Conducting this study and data collection presented several key findings on the gender gap in middle and high school STEM classrooms. Twenty-three educators from a middle and high school district in New Jersey participated in this study. All participants teach in some type of STEM class and were able to provide detailed information on their perceptions of the gender gap in their STEM classrooms. Following the framework of gender schema theory, the aim of this study was to gain insight into the gender gap specifically in STEM, and current teachers' understanding of the discrepancies and strategies used for alleviation of the gap.

RQ1 focused generally on the perceptions that middle and high school teachers have about the gender gap in STEM. As seen in Figure 5, the participants revealed common perceptions regarding differences in confidence levels, stereotypes, maturity and motivation, and external influences that all play a role in the participation of boys and girls in STEM. These final themes all pointed to the fact that STEM teachers have aligned perceptions that boys and girls have differing attitudes and beliefs toward STEM education at the middle and high school levels.

RQ2 addressed the strategies that teachers use to address the gender gap and engage girls in STEM. As seen in Figure 6, all participants expressed that encouragement, building relationships, mentoring, and connection to real-world situations all play a role in girls' attitudes and confidence in STEM. The final themes for the second research question indicated that both building comfort and confidence for girls in STEM and providing female role models with STEM representation are crucial strategies for engaging girls in STEM to close the gender gap.

Major sections to follow include the findings, interpretations, conclusions, limitations, recommendations, and implications for leadership will be addressed.

Findings, Interpretations, and Conclusions

The analysis developed from the two research questions of the study revealed perceptions of middle and high school STEM teachers. The perceptions were specifically related to girls in STEM and the strategies teachers use to engage girls and close the gender gap in STEM classrooms. The basic qualitative study began with an open-ended questionnaire about the perceptions related to gender discrepancies in STEM classrooms. Following the open-ended questionnaire, semi-structured interviews took place to gather more detailed responses and a deeper understanding of teachers' perceptions and strategies for STEM engagement.

Gender schema theory (Zukauskas, 2021) was the basis for the literature review, which provided a framework for the study and led to the findings of the data. According to Starr and Zurbriggen (2017), individuals become gendered in society at an early age and begin to categorize actions and interests such as masculine or feminine. The data gathered from the two research questions exposed how the information synthesized in the literature review, as well as the theoretical framework of gender schema, play a noteworthy role in the gender gap present in middle and high school STEM classrooms.

Reflection on Findings from RQ1

The STEM gender gap, barriers that girls face in STEM, and perceptions of teachers towards STEM education were part of the literature reviewed in Chapter 2. RQ1 asked what are teachers' perceptions about the gender gap in STEM education. Participants identified the various points of view on the gender gap in STEM education and what they witnessed in their own classrooms. One of the major concepts reviewed in the literature that was emphasized during the data analysis was barriers such as stereotype threat and how it impacts the way girls participate in STEM classrooms. Liu (2018) explained that stereotype threat for girls in STEM can cause girls to avoid the subject area and feel undermined when they decide to participate. During data analysis, gender stereotyping was a theme that emerged related to teachers' perceptions of lower confidence levels for girls in STEM subject areas. Gendered stereotyping and stereotype threat also aligned with the negative impacts of gender schema theory because it demonstrates that girls feel that their abilities are linked to their gender and what they believe is a feminine role in the classroom.

Along with stereotype threat, there were general STEM stereotypes that were revealed both during the literature review and the data analysis. One of the stereotypes that aligned between literature and study data was the academic interests that girls hold. During the in-depth interviews and questionnaires, many teachers explained their perceptions in which girls are more interested in subjects closely related to the arts rather than STEM subjects. This concept was also evident in the review of the literature regarding the gender-interest stereotype, where a certain group may have a lower liking, interest, or predisposition to succeed in a certain area compared to another group (Master et al., 2021). When comparing the literature to the data collected from participants, it was evident there was a connection between information from the reviewed literature and information participants discussed form their own perceptions.

Confidence levels were also identified in both the data analysis and literature review. During the literature review, research showed that girls often believe that they are not as good at mathematics as boys and that in general, boys are more successful in STEM. During the data analysis process, it was revealed that many teachers hold the perception that girls are not as confident in STEM, avoid risk-taking, and take a backseat during STEM activities. Both the data and the review of literature align with the notion that expectancy plays a role in the participation of girls in STEM. Maries et al. (2022) explained that girls hold certain expectations about their success in STEM and have lower self-confidence in STEM subjects due to external experiences and factors, yet their academic achievement is not different from boys. Girls are less confident and less comfortable in the STEM classroom, which was discussed in both the literature review and the conversations with participants. Confidence levels are also related to the gender schema theory, as many participants in the study revealed they think girl students are less confident and less likely to participate in STEM because it is a subject meant for boys and they do not feel that they fit in. The perceptions hold that STEM subjects are deemed masculine under the gender schema theory, and girls are not confident to participate.

RQ1 helped to understand the perceptions of middle and high school teachers about the gender gap in STEM subjects. The findings confirmed the knowledge that was found during the review of the literature regarding barriers, stereotypes, and confidence levels of girls in STEM. The data were also interpreted and analyzed through the lens of the gender schema theory. The theoretical framework made the data findings clear that there are gendered perceptions that middle and high school teachers hold regarding the gender gap in STEM classrooms.

Reflection on Findings from RQ2

Various strategies that teachers use to engage girls in STEM and close the gender gap were discussed in the literature reviewed in Chapter 2. These strategies included female role models and mentors, early immersion to STEM, adding the “A” for STEAM, training and education for STEM bias, inclusive and diversified instruction, and STEM experiences outside of school. Of these various strategies discussed in the literature review, some were confirmed during data analysis. Other strategies to engage girls in STEM and close the gender gap were revealed during data analysis, which extend the knowledge in this topic from what was found during the literature review.

One of the findings from the data that confirmed the peer-reviewed literature was to use of female role models and mentors to engage girls in STEM and close the gender gap. Stoeger et al. (2019) explained that having female role models and mentors in the STEM field are very impactful for girls because they have a positive influence and increase their interest in the subject area. The notion of female role models was also present from various participants during data collection.

Participant E stated,

> I’ve tried to find resources that highlight female scientists. For example, a video where a female is the lead scientist or the one disseminating scientific knowledge or images that depict women in science. I’ve learned that representation matters, and I want females to see other females in science.

There were similar responses from other participants in the study as well, which made female role models and the representation of girls in STEM a major theme in the data analysis process. Female role models and mentors also align with the gender schema theory, as it uses the gender schema theory to change the mindset of young girls currently learning the K-12 STEM curriculum. The gender schema theory, in this sense, is used to shift the perspective of subject areas that are masculine or feminine. When girls see there are successful and confident women in the STEM field, it changes their ideology of the STEM field is best suited for men, and they will see that women are just as successful in STEM areas.

Early immersion and exposure to STEM was another theme from the study that confirmed the information gathered during the review of the literature. During the literature review, peer-reviewed sources revealed that piquing girls' interest in STEM early on is vital so that they can develop an interest in STEM early before gender stereotypes develop (Blažev et al., 2019; Sullivan & Bers, 2019). Sullivan (2019) also continued to explain that combating negative stereotypes in STEM early on is crucial so that teachers and parents can help young girls combat those barriers. During data collection and analysis, various participant accounts revealed that they believed exposing STEM to girls at a younger age can be beneficial. Multiple participants explained that by the time students reach middle school, they already hold pre-conceived perceptions of their STEM abilities and interests. Participant H explained that they wished they targeted the gender gap issues in ages as young as kindergarten so that the stereotypes and barriers to girls in STEM are not developed in the first place. This also aligned with the gender schema theory and how teachers believed the gender schema theory plays a role in the early stages of STEM students. The literature review and participant data explained that teachers can help to avoid the negative impacts of the gender schema theory related to STEM pursuit if it is contested at a young age.

Emphasizing the "A" in STEM was another finding that linked the literature review and the participants' responses during data collection. According to Wajngurt and Sloan (2019), when the arts are incorporated into STEM at a young age, there is an increase in girls' STEM interests. This was also a common belief among the participants who were questioned during the semi-structured interview. Participant A stated, "What I've noticed is that boys tend to attract more towards technology-based discussions and more like problem-solving and girls tend to go more towards the creative arts side of everything." Other participants within the study also provided similar responses, explaining that girls in their STEM classes tend to be more creative and pay attention to detail when it comes to the artistic design aspects of projects. The gender schema theoretical framework plays a role in these findings because a common belief is that arts are more feminine, whereas girls typically enjoy and participate in the arts. The findings from the study and the peer-reviewed sources suggest that the gender schema theory can dictate the types of subjects girls may be more prone to pursuing or finding interest in due to the societal norm of artistic subjects being feminine.

Knowledge regarding the strategies to engage girls in STEM and close the gender gap was also extended while exploring RQ2. The knowledge that was extended beyond the peer-reviewed literature has to do with the significance of building confidence and relationships in STEM for young girls, which was a major theme that emerged. Positive relationships and encouragement for girls in STEM were discussed throughout the literature review but did not have a strong emphasis. During data collection, it was evident that many teachers had a strong opinion on the importance of making sure girls feel confident and comfortable in their STEM classes to ensure that they would participate and be active members in their classrooms. Participant D stated, “So, I mean if that’s one of the strategies I use is just making sure that the girls feel equal and if they are performing well to show that they’re dominant in the classroom as well.” Other participants had other similar responses about strategies they use to encourage girls and make them feel that they belong in STEM. This extended knowledge is a representation of how STEM teachers can play an active role in eliminating the negative impacts of gender schema on girls’ academic interests.

Limitations

Although the study had various limitations, measures were taken to mitigate the limitations and create full transparency without breaking any ethical codes. One of the limitations that was present in the study was the sample size of 23 teachers being only within

STEM fields. The restriction on subject areas ultimately eliminates other subject areas such as social studies, English, and other elective areas, which can harm the transferability of the study. According to Rodon and Sesé (2008), the transferability of research results depends on the fit between the common features and characteristics from one study to the other. In this study, the setting took place in a middle and high school district, so to promote transferability, the study would be best replicated in another middle and high school district. To increase transferability and alleviate transferability threats, this study utilized full transparency and full description to ensure the study could be implemented and followed for other research purposes (Coleman, 2021). The study was described in full detail without exposing any identifying factors of participants, so other researchers will be able to transfer and replicate the study to adhere to the scope of their own research.

Another possible limitation of the study was researcher bias, which can negatively impact credibility. Onwuegbuzie and Leech (2007) explained that researcher bias can affect the data collection techniques and study procedures and can also reflect biases that can transfer to participants, which can sway participants' behaviors and attitudes. To avoid the harms of researcher bias on credibility, reflexivity was ensured. Applying reflexivity within the study increased the awareness of the researcher to recognize their influence on the study and how their own perceptions can affect data collection and analysis (Mackieson et al., 2018). Reflexivity was maintained throughout the study by completely disclosing all questionnaire and interview questions to ensure trustworthiness and transparency during data collection.

Triangulation was used as a method for ensuring validity and dependability. Although there are different methods of triangulation, methodological triangulation was specifically used for this study. Methodological triangulation is the use of several data collection methods such as interviews and observations to increase credibility, validity, and dependability (Noble & Heale, 2019). To apply triangulation, two different data collection tools were used including the questionnaire and semi-structured interview. Using various data collection instruments allows for analysis of alignment between findings within the two data sets to help form a cohesive interpretation (Coleman, 2021). Triangulation ensures dependability because the cross-checking of data makes the analysis and interpretation more trustworthy and reliable. Triangulation further ensures validity because the use of the two data collection tools promoted a more accurate reflection and evaluation of the participants' responses about the gender gap in their STEM classrooms (Noble & Heale, 2019).

Confirmability is the assertion that the data and findings are not due to participant or researcher bias (National University, 2023). To assure confirmability, a researcher must continuously check data through the data collection and analysis process (National University, 2023). To maximize confirmability in the study, data were thoroughly sorted throughout the transcription and coding processes. Data were double-checked by re-listening to the recording during transcription so that there were no mistakes throughout the analysis process. In addition, open coding was used so that researcher bias could not play a role in the data analysis process.

Recommendations

Shifting to a more global perspective, STEM teachers around the world should be aware of the discrepancies between girl and boy students in the STEM classroom. Being aware of these differences further implies that teachers should have the proper training and knowledge on reaching and inspiring girls in the STEM classroom, in addition to having personal repertoires of strategies to increase STEM engagement. Research found that girls in STEM classes are often aware of the biased messages that boys are superior in STEM, which makes girls' encounters with STEM more triggering and filled with self-doubt (Berwick, 2019). Developing teachers' understanding of this gender gap issue and equipping them with a variety of strategies to encourage girls in STEM and build confidence will result in improved learning outcomes (Berwick, 2019).

A recommended change in policy and practice that could help alleviate the gender gap in middle and high school STEM classrooms would be adjustments to STEM teacher preparation programs. Many STEM teacher preparation programs emphasize the need for certifications, endorsements, and strategies for developing STEM curricula and lessons. These preparation programs designed by educational stakeholders should also address the issues with the gender gap in STEM classrooms and should teach future STEM teachers about the different methods to address gender disparities in the classroom. Along with addressing the gender gap issues, the STEM teacher preparation programs should equip teachers to practice various strategies of engaging and piquing the interest of girls in STEM classrooms. With an increased number of teachers having knowledge and ability to address the gender gap and grow girls' interest, there will be more girls with a positive influence and yearning to pursue STEM as a coursework and future careers since the issues were addressed early enough. Researchers also surmised that instilling a growth mindset is beneficial for girls in STEM. With a growth mindset, girls can easily understand that performance in STEM takes practice, rather than innate ability and training and hard work will help them persist through challenges and excel in the STEM field (Berwick, 2019). Practitioners and policymakers should ensure that knowing how to teach a growth mindset to girls in STEM is a requirement so it can be incorporated in STEM classrooms around the world.

Further research on this subject should include the relationship between teachers' perceptions of the gender gap in STEM and students' perceptions. The literature reviewed during Chapter 2 suggested there are many spheres of influence on girls' participation in STEM, including teachers. Teachers are one of the categories that can have an influence on students' interests and aspirations (Coenraad et al., 2021). Further research should investigate if teachers' STEM perceptions, whether positive or negative, influence the way girls view themselves and their future in STEM courses and careers. In addition, further research should investigate how teachers may deflect their own perceptions of students and influence them to either pursue or avoid the STEM field.

Other aspects of further research should consider the maturity and motivation of students at the middle and high school levels toward STEM. One of the major themes that emerged from the first research question on teachers' perceptions was girl and boy students' maturity and motivation played a role in how they participated in STEM courses differently. Teachers explained that because girls are more mature and motivated than boys, they were less likely to take risks for fear of failure, were less outspoken, and less likely to participate confidently. Further research should investigate how maturity for boys and girls in middle and high school plays a role in their course selection and their career interests. Researching this topic further could uncover the reasoning behind why fewer girls choose to participate in STEM courses, which is the main contributor to the gender gap issue in STEM.

Implications for Leadership

The findings of this study indicate there is a need for positive social change regarding the way girls in STEM are taught, engaged, and encourage. The next step towards making a positive social change will be to share these results with school district officials to promote awareness of the current STEM gender gap issues. Sharing these results will help to address the gender gap perceptions relative to the needs of individual schools. Based on the data and findings, schools and families can make changes to address the gender gap that we continue to see in STEM education.

K-12 Schools for Positive Social Change

K-12 school districts are pivotal for initiating positive social change toward the gender gap in STEM education. One strategy that schools can use to address the gender gap in STEM is to focus on enrolling and recruiting more girls to participate in STEM coursework. Milgram (2011) explained that reaching out to counselors is crucial because they can provide a pathway toward STEM for female students and inform administrators and teachers of the opportunities in STEM for girls. Enrollment and recruitment strategies will be beneficial for addressing the gender gap in STEM because it increases the number of girls in the classroom, therefore helping girls feel more comfortable and accepted. Based on the data and findings, teachers perceive that girls are not as comfortable in the STEM classroom because it is typically dominated by students who are boys. Leaders of schools focusing on implementing strategies to increase the enrollment of girls in STEM is one step in the direction towards positive social change.

Another aspect of the data findings suggests that teachers perceive their girl students are more comfortable and confident in STEM when they are surrounded by other girl peers. According to Milgram (2011), there are many after-school, girls-only programs that have been founded to increase the number of girls in STEM and address the gender gap. School stakeholders such as administrators and teachers can start clubs in their school that are specific to girls seeking STEM engagement within a comfortable, safe space. These girl-only STEM clubs ultimately can help build confidence in STEM and help girls understand they belong in STEM.

An increased sense of belonging for middle and high school girls in STEM will produce a positive social change that originates with their school stakeholders.

Teachers can take it upon themselves to push toward positive social change for middle and high school girls in STEM. One of the ways teachers can play a role in this change is by participating in professional development on understanding the gender gap issue and how to properly address it. From the data and findings of the study, teachers have perceptions that STEM is not as exciting to their girl students since the girls have other interests such as the arts. With this type of perception, it can cause teachers to send negative subliminal messages about what subject or interest girls should and should not pursue as an academic endeavor. According to Milgram, teachers are some of the many people in a young girl's life that can send a negative message about their participation in STEM. Even when it is not intentional, teachers can send the message to girls that STEM is not for them and not a career they can or should pursue (Milgram, 2011). Teachers can implement positive social change by educating themselves on the ways to properly help girls understand they can succeed in STEM. With the proper professional development training, teachers will have a better understanding of how to increase interest and motivation for girls in STEM, ultimately creating a positive social change for the gender gap.

Families for Positive Social Change

Parents play a very large role in the potential for positive social change for the gender gap in STEM education. In general, parents' perceptions and beliefs are correlated to those of their children. According to Eccles (2015), there is an impact on a child's own expectancies and values in STEM based on the expectations, and values of their parents. If a parent has low expectations for their child in math, especially for girls, then the girls are more likely to have similarly low expectations and lower confidence about their math abilities (Eccles, 2015). Based on the findings of the study, teachers perceive that girls often lack confidence in STEM areas and are less likely to pursue STEM subjects. Since parents have such a substantial impact on their children and their perceived STEM abilities, they can use their influence for positive social change. Helping their daughters by encouragement, increasing STEM involvement, and taking opportunities for their daughters to participate in STEM outside of the classroom are simple methods to implement social change. Increasing engagement can be accomplished via attending STEM-related day camps or workshops to get informally involved in STEM by making it more comfortable and approachable for young girls.

Conclusion

The basic qualitative study explored teachers' perceptions of the gender gap in middle and high school STEM classrooms. The study took place in a central New Jersey middle and high school district, with a total of 23 teacher participants. The study sought to gain in-depth knowledge of teachers' perceptions of the gender gap and the strategies they use to engage girls and lessen the gap.

Through analysis of the open-ended questionnaires and semi-structured interviews, the study's key points emerged from the six themes that were developed in Chapter 4. Four of those themes related to RQ1 on teacher perceptions of the gender gap were: (a) confidence levels, (b) stereotypes, (c) maturity and motivation, and (d) external influences. The additional two themes were related to RQ2 on the strategies to address the gender gap and engage girls in STEM, which were: (a) building comfort and confidence and (b) female role models and representation.

The study could contribute to understanding the need for further research on lessening the gender gap in STEM education. Conducting this study revealed that many teachers have perceptions and opinions about the gender gap in their STEM classrooms but do not have knowledge of the effective strategies to help alleviate the gap. Recommendations generated from this study include adjusting STEM teacher preparation programs so that STEM teachers enter the field understanding the gender gap issue exists and are already aware of methods for engaging girls. Teachers must understand the influence they have on young girls and their academic pursuits so that they can help them navigate a male-dominated field if they choose STEM as a pathway.

Schools and families can utilize the findings of the study to increase awareness of the current gender gap issues in STEM education and create initiatives toward social change in the field. Based on the data, educators perceive STEM education as a critical learning experience in which girls should feel equally as comfortable and confident as boys. This study's findings have shown that with further research and educational training on engaging girls in STEM, the STEM gender gap can see eventually a reprieve.

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Appendix A

Invitation to Participate

Date: Dear (name of participant),

I am a doctoral candidate at American College of Education. I am writing to let you know about an opportunity to participate in a dissertation research study.

Brief description of the study: This will be a study to examine middle and high school teachers' perceptions of the gender gap in STEM classrooms.

Description of criteria for participation:

- Any teacher who has been teaching for at least three years
- Any teacher who teaches science, technology, engineering, or mathematics (STEM) subjects

Your participation in the study will be voluntary. If you wish to withdraw from the research at any time, you may do so by contacting me using the information below.

I may publish the results of this study; however, I will not use your name nor share identifiable data you provided. Your information will remain confidential. If you would like additional information about the study, please contact the following:

Candidate Contact Information: Danielle Andreula [redacted]

Chair Contact Information: Dr. Joshua Strate [redacted]

If you meet the criteria above, are interested in participating in the study, and would like to be included in the potential participant pool, please come see me in person or send an email to the above address.

Thank you again for considering this dissertation research opportunity.

Sincerely,
Danielle Andreula

Appendix B

AMERICAN COLLEGE of EDUCATION

Informed Consent Letter

Prospective Research Participant: Read this consent form carefully and ask as many questions as you like before you decide whether you want to participate in this research study. You are free to ask questions at any time before, during, or after your participation in this research.

Project Information

Project Title: Teacher Perceptions of the Gender Gap in STEM Education: A Basic Qualitative Study

Researcher: Danielle Andreula
Organization: American College of Education
Email: [redacted]
Telephone: [redacted]

Researcher's Dissertation Chair: Dr. Joshua Strate
Organization and Position: American College of Education
Email: [redacted]

Introduction
I am Danielle Andreula, and I am a doctoral candidate at American College of Education. I am doing research under the guidance and supervision of my Chair, Dr. Joshua Strate. I will give you some information about the project and invite you to be part of this research. Before you decide, you can talk to anyone you feel comfortable with about the research. This consent form may contain words you do not understand. Please ask me to stop as we go through the information, and I will explain. If you have questions later, you can ask them then.

Purpose of the Research
The purpose of this basic qualitative study will be to investigate a New Jersey middle and high STEM teachers' perceptions of the gender gap in STEM classrooms. You are being asked to participate in a research study which will assist with understanding the gender gap in STEM classrooms in our school. Conducting this qualitative methods study will help identify the shortcomings of the current STEM instruction practices to close the gender gap in STEM education.

Research Design and Procedures
The study will use a qualitative methodology and a basic qualitative research design. The study will comprise of 15 participants who will participate in this research. Only teachers who have been teaching for at least three years and teach a STEM subject will be eligible. The study will involve a questionnaire and an interview to be conducted at a site most convenient for

participants. If participants wish, there will be an optional debriefing session after the interviews have been conducted.

Participant selection
You are being invited to take part in this research because of your experience as STEM teacher who can contribute much to the gender gap in STEM.

Voluntary Participation
Your participation in this research is entirely voluntary. If you choose not to participate, there will be no punitive repercussions.

Right to Refuse or Withdraw
Participation is voluntary. At any time, you wish to end your participation in the research study, you may do so by sending me an email explaining you are opting out of the study. There will be no repercussions for leaving the study.

Procedures
We are inviting you to participate in this research study. If you agree, you will be asked to participate in a Google Forms open-ended questionnaire and an interview. The type of questions asked will range from a demographical perspective to direct inquiries about the topic of the gender gap in STEM classrooms. Interviews will be video and audio recorded for later data analysis.

Duration
The questionnaire portion of the research study will require approximately 10-15 minutes to complete. The interview portion of the research study will require approximately 45 minutes to an hour to complete. If you are selected to participate in the study, the time expected will be a maximum of an hour and 15 minutes at a location and time convenient for you. Prior to an interview, you will be asked to provide permission to have the interview recorded for the sake of having accurate transcripts for data.

Risks
The researcher will ask you to share personal and confidential information, and you may feel uncomfortable talking about some of the topics. You do not have to answer any questions or take part in the discussion if you don't wish to do so. You do not have to give any reason for not responding to any question.

Benefits
While there will be no direct financial benefit to you, your participation is likely to help us find out more about the gender gap in STEM classrooms. The potential benefits of this study will aid the school district in assessing methods and strategies for closing the gender gap in STEM subjects.

Confidentiality
I will not share information about you or anything you say to anyone outside of the researcher. During the defense of the doctoral dissertation, data collected will be presented to the

dissertation committee. The data collected will be kept in a locked file cabinet or encrypted computer file. Any information about you will be coded and will not have a direct correlation that directly identifies you as the participant. Only I will know your identity, and I will secure your information. After 3 years, all data will be destroyed.

Sharing the Results
At the end of the research study, the results will be available for each participant. It is anticipated to publish the results so other interested people may learn from the research.

Questions About the Study
If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact me at [redacted]. This research plan has been reviewed and approved by the Institutional Review Board of American College of Education. This is a committee whose role is to make sure research participants are protected from harm. If you wish to ask questions of this group, email IRB@ace.edu.

Certificate of Consent
I have read the information about this study, or it has been read to me. I acknowledge why I have been asked to be a participant in the research study. I have been provided the opportunity to ask questions about the study, and any questions have been answered to my satisfaction. I certify I am at least 18 years of age. I consent voluntarily to be a participant in this study.

Print or Type Name of Participant: ______________________________

Signature of Participant: ______________________________

Date: _________________

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily. A copy of this Consent Form has been provided to the participant.

Print or type name of lead researcher: ____

Signature of lead researcher: _____________________________________

Date: _______________________________

PLEASE KEEP THIS INFORMED CONSENT FORM FOR YOUR RECORDS.

Appendix C

July 25, 2022

Dr. Amy Stella

Acting Superintendent

Dear Dr. Amy Stella:

My name is Danielle Andreula, and I am a doctoral candidate at American College of Education (ACE) writing to request permission to send questionnaires and interview STEM teachers in the [redacted] Regional school district who have at least three years of teaching experience. This information will be used for my dissertation research related to Teacher Perceptions of the Gender Gap in STEM Education. The purpose of the basic qualitative study will be to investigate a New Jersey high school and middle school STEM teachers' perceptions of the gender gap in STEM classrooms. Doing this will help identify the shortcomings of current STEM instruction practices to close the gender gap in STEM education.

I am looking into recruiting any teachers who teach STEM subjects from both the middle and high school and plan to include a final population of 30 participants.

Principal Investigator: Danielle Andreula

E-mail: [redacted]

Phone: [redacted]

Dissertation Chair: Joshua Strate
E-mail: [redacted]

Thank you for your attention to this issue and prompt response. I appreciate your time and consideration of my request.

Regards,

Danielle Andreula

Appendix D

[redacted]

[redacted]
Acting Superintendent of Schools
[redacted]

[redacted]

[redacted]
Business Administrator/Board Secretary
[redacted]

July 25, 2022

Dear Ms. Andreula:

This letter serves as confirmation of district approval to conduct your dissertation research on *Teacher Perceptions of the Gender Gap in STEM Education* in the [redacted] Regional School District. Specifically, you may send questionnaires and conduct interviews with teachers of STEM related subjects who have at least three years of teaching experience. Upon completion, please provide us with a copy of your final dissertation to support our implementation of instructional practices to close the gender gap in STEM education.

Best wishes with your research.

Sincerely,

[redacted]

[redacted]
Acting Superintendent of Schools

[redacted]

Appendix E

Teacher Perceptions of STEM Gender Gap Questionnaire

Research Question 1: What are teachers' perceptions about the gender gap in STEM education?

Research Question 2: What strategies do teachers use to address the gender gap and engage girls in STEM education?

[redacted] (not shared) Switch account

I teach in a STEM subject area (Yes/No)

Your answer

You have an equal percentage of boys and girls in your classes? (Yes/No) if no, please elaborate

Your answer

Boys and girls equally interested and engaged in the STEM subject area that you teach? (Yes/No) If no, please elaborate

Your answer

Boys and girls equally decide to pursue STEM after taking your course (Yes/No) If no, please elaborate

Your answer

You use strategies to increase interest and engagement specifically for girls in your classroom (Yes/No) If yes, please elaborate

Your answer

Girls typically take a "backseat" in STEM classes while working with boys in group work (Yes/No) Please elaborate.

Your answer

Getting girls to enjoy STEM is difficult (Yes/No) Please elaborate.

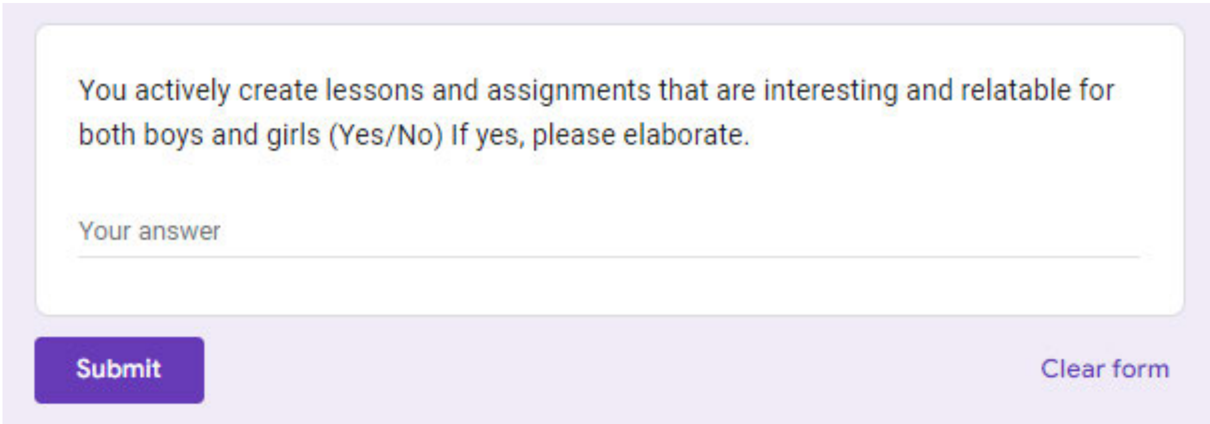
Your answer

Girls are better at subjects pertaining to the arts, while boys are better at STEM subjects (Yes/No) Please elaborate.

Your answer

Teachers can make a difference and influence girls to pursue STEM (Yes/No).

Your answer



You actively create lessons and assignments that are interesting and relatable for both boys and girls (Yes/No) If yes, please elaborate.

Your answer

Submit

Clear form

Appendix F

Opening Interview Protocol:
Interview Date and Time: ____________________________
Interview Location: ______________________________
Name of Interviewer: ___________________________

"Hello, my name is Danielle Andreula and I am a doctoral candidate seeking to facilitate a semi-structured interview for doctoral research. The purpose of this study is to gather perceptions of middle and high school teachers on the gender gap in STEM classrooms. All responses will remain confidential. Participation in this interview session indicates that you have already signed informed consent. Your honest responses will help gain insight into possible means of lessening the gender gap in STEM education.

Introductory/Demographic Questions:
1. What gender do you identify as?
2. How many years have you been teaching?
3. What made you decide to become a teacher in a STEM subject area?

Interview Questions:
4. Can you please describe your typical classroom makeup based on gender ratios?
5. What are your experiences of gender disparities in your STEM classroom?
6. What do you think may be part of the reason for any gender differences you see in your classroom?
7. How do you adjust or inform your instruction to make sure it is engaging and interesting for all genders in your classroom?
8. What challenges or obstacles do you face when attempting to get both boys and girls interested in the STEM subject matter?
9. What obstacles do you typically face when implementing STEM subjects for girl students?
10. Can you please explain the strategies you try to use to help engage girls in STEM?
11. Over the years that you have been teaching, has the gender gap in STEM subjects changed or improved?
12. What do you believe needs to be implemented or changed in order to address the gender gap in STEM classrooms?

Note. This is a semi-structured interview where follow-up questions and continued conversation will occur during the interview.

Closing Interview Protocol:
"Thank you for participating in this semi-structured interview session. Your responses are completely confidential. If you have any further questions regarding the study, please feel free to ask now, or reach out to me directly at a later time. Your time is greatly appreciated."

Appendix G

Subject Matter Experts Feedback

Subject Matter Expert (SME) email request:

I am currently writing my dissertation methodology section and I needed to contact 3-5 Subject Matter Experts (SME). Basically, I must reach out to people who are knowledgeable in the content area that I am writing about. From the SME's, I need feedback on the questionnaire and interview questions that I came up with. I was wondering if you could look at those two things and provide some feedback

Feedback could include alignment of the research questions and interview questions, or if anything is written in a way that is difficult to understand. Both positive and constructive feedback are welcome!

Thank you,
Danielle Andreula

RESPONSES:

Subject Matter Expert 1
Matthew Konowicz
STEM Curriculum Director of Instruction
[redacted]

It would be my pleasure to help you…

Typo "**Research Question 4:** What are the strategies teachers use to address the gender gap and engage girls in <u>in</u> STEM education? "
Asking if there is "a large number of boys/girls" is vague. Clean data may be collected if you ask in terms of % and provide options, like more less than 10%, 40%, etc...
A term to reconsider… equally "interested" in STEM.. a more common term used is "engaged or engagement".
I am not sure if you can ask other question types beside agree/disagree. I don't think this question is really addressed "**Research Question 3:** What are the obstacles teachers face when implementing STEM education for girl students?" Can you provide what you think are the top 4 obstacles and see if respondents agree/disagree with you?

(ohh I see, the second document address some of my thoughts above)

When interviewing, is it important to ask or record what gender the person identified as? I would be curious to see if men and women teacher have differing opinions.
I wonder how much impact the school or district has on the class ratios, the obstacles, the potential for more women in STEM? Often the counselor is the biggest contributing factor to placing students in certain courses. Can you add them to you interview or are you only focused on teachers? Perhaps ask teachers specifically about the counselor's impact on course selection. You can also ask perceptions on parent impact and student peer impact on course selection.

As I review this, I also wonder how recent attention to gender identity could be referenced in your research. I wonder if there are certain characteristics of a person, no matter what gender they identify as, that would have an impact on their interests or success in STEM.

Good luck-

Mr. Matthew Konowicz
Director of Instruction
https://www.njstemteachers.org/ *Guide to becoming a teacher in NJ.*
Agriscience, Applied Technology, Business, Family Consumer Science,
Visual & Performing Arts, Video Production/Northern TV
[redacted]

Subject Matter Expert 2
Kerry Curran
Middle School STEM Teacher
[redacted]

As a female middle school STEM teacher, this topic is very important to me as I see it and experience the gender gap first hand. I appreciate your hard work you've put into this topic to find out what more can be done to close the gap!

I really like Interview question #10 and am curious to see what kind of responses there are. I think something that could be interesting to add to the research would be to interview different grade level STEM teachers. I have found through experience and discussion that the gender gap in STEM is present through all years, but would be interested in finding out why it continues through high school. Some schools are starting STEM at the elementary level. Finding out what type of STEM activities are completed at that age level and how the students feel about it at a young age may add to the research. It could be interesting to hear how middle school teachers experience the gender gap compared to high school teachers.

Going off Interview Question #4, I think finding out more of what type of students are in the classroom could be helpful! What do you notice about the difference in the way the boy versus girl students complete your stem course? What type of students are they in the STEM classroom? Out of the STEM classroom? How do they engage in the activities and curriculum? What do you notice is a common theme that the majority are engaged in (group work, robotics, sketching, partner activities)?

Getting more female students involved would bring so much to the STEM world! Awesome job & best of luck with the rest of your research!

Sincerely,
Kerry Curran
[redacted]

Subject Matter Expert 3
Nicole DiMaiuta
Upper Elementary STEM/Enrichment Teacher
[redacted]

Overall, I believe the subject matter pertaining to the interview, research, and questionnaire are very interesting. It is a topic that I believe we should be discussing and you were able to actively get the respondent to start thinking about it. A suggestion I have pertains to the interview portion; I would ask the interviewee more questions in regards to their background/personal experiences. I believe that will directly correlate with some of the responses you might receive and provide you with a better understanding as well. Some people might be more biased or opinions might change based on their own experience in the field, gender, education, knowledge, etc. You addressed Research Question #2 nicely throughout the questionnaire, specifically through the last few questions/statements. It is informative to know what educators' perceptions are, however, it is even more important to know how their view or understanding impacts their instructional practices.

Overall, nice work!

--
Nicole DiMaiuta
[redacted]