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An Exploratory Case Study On Elementary Education Teacher Candidates' Perception Of The Gender Gap In Science And Exposure To The Topic From Their Educator Preparation Program Curriculum

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AN EXPLORATORY CASE STUDY ON ELEMENTARY EDUCATION TEACHER CANDIDATES' PERCEPTION OF THE GENDER GAP IN SCIENCE AND EXPOSURE TO THE TOPIC FROM THEIR EDUCATOR PREPARATION PROGRAM CURRICULUM

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ABSTRACT

Despite much progress, the gender gap in science still persists, and it is imperative that researchers continue addressing the problem at all levels, in the hope that the combined efforts of all investigations and initiatives will eventually work to close the gap. This qualitative exploratory case study, rooted in a social constructivist and feminist paradigm, investigated elementary education teacher candidates' perceptions toward the gender gap in science, their attitudes and responsibilities toward closing it, and their potential strategies to encourage female student interest in science. It also investigated their exposure to the topic of the gender gap in science from the educator preparation program (EPP) they were enrolled in, including a variety of artifacts and their teacher educators' shared perceptions on the topic.

These two facets, being directly linked to the field of elementary education, fill a niche in the literature relevant to the gender gap in science. Personal interviews and a curriculum artifact analysis protocol were utilized as the primary data collection tools. The results of the study were that elementary education teacher candidate participants had varying levels of understanding and varying levels of confidence in their understandings of the gender gap in science but thought that it was a problem that could be addressed by teachers. However, they felt personally less responsible and/or that taking on the responsibility was intimidating. The elementary education teacher candidates shared strategies to engage female student interest in science, with the origin of some of the strategies attributed to the EPP curriculum. Some of the teacher educator participants used strategies that elementary education teacher candidates could use to engage

female elementary students in science but most used strategies that their elementary education teacher candidates could use to engage *all* elementary students in science.

According to elementary education teacher candidate participants, the topic of the gender gap in science had not been addressed in their coursework. This finding was solidified by the result that only one out of five of the teacher educator participants directly addressed the gender gap in science topic with his students. All of the teacher educator participants indirectly addressed the topic of the gender gap in science with their classes. The analysis of the curriculum artifacts, syllabi, and required textbooks that corresponded to courses taught by the teacher educator participants to elementary education majors confirmed the findings from the interview data. The gender gap in science was not explicitly addressed in a single artifact.

Just as teacher educators indirectly addressed the problem, the artifacts contained a number of items that may be considered advantageous to promoting student interest and motivation in science, thus indirectly impacting the gender gap in science. Teacher educator participants shared strong thoughts about their elementary education teacher candidates and science as well as their habits of supporting and encouraging their elementary education teacher candidates. All teacher educator participants confidently acknowledged the gender gap as a problem that persists in science but acknowledged that progress has been made. Teacher educator participants, although confident that the gender gap in science persists, were unsure whether the EPP has the capacity to address the gender gap in science or whether they were personally responsible to address the topic with their classes.

The results of this study chip away at the androcentric bias that still permeates the field of science. Many of the results corroborated the literature whereas some results were an extension to it and still others were unique ideas compared to the review of literature conducted for this study. Specifically, the connection of the topic of the gender gap in science with that of educator preparation fills a deficit in the literature. With regard to the theoretical framework, elements of personal and social constructivism corroborated the literature but that of multiple intelligences theory was almost completely missing from the results of the current study. Also within the theoretical framework, corroboration was found with regard to feminism in the lack of acknowledgement/knowledge of the problem among female elementary education teacher candidate participants. Pertaining to the hybrid paradigm of this study, the enormous amount of detail and variety within the results speak to the multiple realities view of both the social constructivist and feminist paradigms.

Although literature support for the ability of social justice educators was found, the results of this study explicitly expressed that only one teacher educator participant shared personal experiences as a teaching strategy. Of the many teaching strategies presented in the literature, only some were expressed in the results of the current study. Vice versa, ideas/strategies, different from the literature review, regarding the promotion of elementary student interest in science surfaced in the results. The absence of the explicit address of the gender gap in science by four of the five teacher educator participants, as well as its complete absence from the curriculum artifacts, was congruent with the idea that gender equity is only addressed minimally and superficially within an EPP. Also congruent with the literature were results which expressed the lack of gender gap in science seen at the elementary level, the dearth of science teaching in elementary schools, the low self-confidence of elementary teachers, and the lack of science taken by elementary education majors within their EPP. Pertaining to the opposite gender gap seen among elementary teachers, the results of this study did not express

knowledge of nor support for the use of this opposite gender gap as a tool to impact positively the gender gap in science.

In response to the cumulative results of the elementary education teacher candidate participant interview data, the teacher educator participant interview data, and the curriculum analysis data, recommendations for three different stakeholder groups were developed. The topics and experiences discussed by participants, as well as the presence or absence of the topic of the gender gap in science being directly addressed by the curriculum artifacts, provided a foundation for these recommendations. The recommendations for elementary education teacher candidates include conducting personal reflection on science experiences, breaking the cycle of a lack of science teaching at the elementary level, knowing learner characteristics, doing hands-on science, building a science network, using female scientists in the curriculum, being a science role model, assigning projects to interested students, sponsoring a science club, and making real-life connections. The recommendations for the EPP/teacher educators include adding the gender gap in science topic to the curriculum, adding a new course to the curriculum, learning about the science teaching of cooperating teachers before placing students, sharing personal experiences with students relative to the gender gap in science, and establishing formal partnerships with elementary education majors. The recommendations for future researchers include conducting action research on the impact of adding the topic of the gender gap in science to the EPP curriculum, determining the amount of hands-on science being conducted by elementary education teacher candidates during student teaching, and identifying a successful science network as a model.

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CHAPTER 1

INTRODUCTION

The literature available on the topic of the gender gap relative to science, technology, engineering, and mathematics (STEM) is abundant, and the variety of subtopics focused upon is wide. Research shows that although in some areas the gap has narrowed or even closed, there is still a need to investigate further many gender gap subtopics, specifically interest toward the STEM subjects (Cunningham & Hoyer, 2015). In line with the wide array of research on the topic, come numerous explanations for the gender gap in science including cultural, attitudinal, and age-related rationalizations (Baram-Tsabari & Yarden, 2011).

But why is the gender gap in STEM fields a problem with which to be concerned? According to Beede et al. (2011), a major reason is the dependency of our nation's international competitiveness on STEM careers. After analyzing 2009 data obtained from the American Community Survey public-use micro database, Beede et al. found that women occupy 48% of all jobs but only 24% of STEM jobs and that there is a 14% gender wage gap for STEM jobs. From 2000 to 2009, the percentage of females occupying STEM jobs has remained stagnant at 24%. With data that exemplifies no change in nearly a decade, there is still a need to combat the gender gap in STEM areas. We must look for innovative ways to study the topic and find new approaches to combat the problem. On a grand scale, it is imperative that researchers continue addressing the problem at all levels in the hope that the combined efforts of all investigations and initiatives will eventually work to close the gap.

Purpose of the Study

The purpose of this qualitative exploratory case study was two-fold. First, it sought to investigate elementary education teacher candidates' perceptions toward the gender gap in science, their attitudes and responsibilities toward closing it, and their potential strategies to encourage female student interest in science. Second, it sought to investigate teacher candidates' exposure to the topic of the gender gap in science from the educator preparation program (EPP) they are enrolled in, including a variety of artifacts and their teacher educators' shared perceptions on the topic. These two facets, being directly linked to the field of elementary education, fill a niche in the literature relevant to the gender gap in science.

Significance

The study is significant because it adds to the research base on the gender gap in science, focusing on the perceptions that new teachers will bring with them into the elementary classroom. As instructors of the biggest pipeline for potential future female scientists, it is critical to understand not only their perceptions toward the gender gap but their exposure to the topic in their EPP. Additionally, this study has identified specific teaching strategies that are being used by the EPP that, once employed by the new elementary school teachers, have the potential to increase female student interest in science. There is an abundance of literature available on the gender gap in science as well as elementary educators. However, limited studies are available that combine the two topics directly. This study is significant in forming an intersection between these facets.

Research Questions

1. What perceptions do elementary education teacher candidates hold relative to the gender gap in science?
2. What perceptions do elementary education teacher candidates hold relative to their responsibilities in closing the gender gap in science?
3. What perceptions do elementary education teacher candidates hold about taking on responsibilities toward closing the gender gap in science?
4. What ideas/strategies do elementary education teacher candidates possess that may afford them the opportunity to engage female student interest in science?
5. How does the curriculum of the EPP address the gender gap in science?
6. What perceptions do teacher educators at the EPP hold relative to the gender gap in science that they share with their elementary education majors?

Definition of Terms

The following term definitions are presented as they were operationally employed in this study.

Case Study – A case study investigates multiple components of a specific setting relevant to a particular topic. For this study, the case will be composed of individuals and artifacts relevant to a particular university's elementary education program.

EPP – An EPP is a program at an institution of higher education, which prepares teacher candidates to become professional educators. Educator preparation programs are also often called teacher preparation programs.

Elementary Education – Elementary education is an undergraduate major of study, which prepares university students to earn a teaching license and teach grade levels kindergarten to six.

Gender Gap – A gender gap may be a difference between the numbers of female versus male individuals within a particular context. For this study, the gender gap in science, historically dominated by male individuals is addressed.

Science – Science is any subject that investigates the natural world. It includes but is not limited to any life or physical science.

Organization of the Study Presentation

This dissertation is divided into five chapters. Chapter one provides an introduction to the study, including the purpose, significance, research questions, and definition of key terms. Chapter two provides a review of the literature related to the subtopics of the gender gap in science, a brief historical overview and progress, impact of elementary educators on the gender gap in science, and present-day challenges. Additionally, literature relevant to educators and the gender gap in science, including their awareness, attitudes, and teaching strategies, are addressed. Chapter two also presents information on the curriculum in Indiana elementary schools and the respective schedules to which elementary educators adhere. Lastly, chapter two presents the need for the study relative to the literature that is available on the topic.

Chapter three provides information about the methods that were employed in the study. The research questions and the qualitative paradigm and approach are discussed as well as a relevant course-based inquiry project conducted by the author. Chapter three also delineates the design of the study including the interview protocols, curriculum analysis protocol, setting and participants, data collection and analysis, and ethical concerns relevant to utilizing human participants. Chapter four provides information about the results of the study, ascertained from the analysis of data collected via personal interviews with elementary education teacher candidate participants, personal interviews with teacher educator participants, and the curriculum artifacts. The results in chapter four address the research questions of the study plus additional themes that emerged from the data. Participants' backgrounds and demographic information, perceptions of the gender gap in science and responsibilities, and elementary education teacher candidates' exposure to the topic of the gender gap in science from their EPP are the three major sections of chapter four, which envelop the detailed results. Chapter five summarizes the study and the results, discusses the implications of the results, and provides recommendations for several stakeholders as well as future research.

Summary

In this introductory chapter, the purpose of the study has been explained. Simply, it is two-fold in nature as both the elementary educator candidates' perceptions of the gender gap in science and the exposure to the topic from their EPP are critical elements. The significance of the study has also been delineated and comes from the ability of this study to fill a gap in the literature. By grasping an understanding of the perceptions held by elementary education candidates relative to the gender gap in science, as well as how their EPP curriculum has addressed the topic, a combination of education and the gender gap in science has been established. There are six research questions in this qualitative study that were used to target both the perception of the teacher candidates relative to the gender gap in science as well as how the curriculum of their EPP has addressed it. The terms that are relevant to his study have been defined and include case study, educator preparation program, elementary education, gender gap, and science.

CHAPTER 2

REVIEW OF THE LITERATURE

Overview of the Gender Gap in Science

Theoretical Framework

Constructivism, feminism, and the theory of multiple intelligences each offer a benefit to this study. Constructivism and multiple intelligences address how teaching and learning may transpire successfully, especially by addressing alternative conceptions and the unique strengths of learners; feminism puts the topic of the gender gap at the forefront. It serves as a reminder that it is critical to understand the underlying restraints to gender equity in science. Identifying the presence or absence of specific strategies, such as constructivist and multiple intelligences-based approaches, used by EPPs to prepare teacher candidates to combat the gender gap, as well as understanding the participants' shared experiences related to the topic, are essential. By connecting these learning theories to feminist theory and the problem of the gender gap in science, this study has the opportunity to supply information that will make a difference.

Constructivism is a learning theory that has maintained popularity in science education for quite some time. However, Bachtold (2013) addressed the ambiguity found within seminal constructivist papers focusing on science education and attempted to better define what science students should actually be constructing according to the theory of constructivism. First, a distinction must be made between Piaget's cognitive personal constructivism (PC) and

Vygotsky's social constructivism (SC). Each is considered a part of the process of learning science via constructivism. With regard to PC, students subconsciously develop concepts on their own according to their interactions with the material environment. Additionally, but not unrelated, students come into science class with "alternative conceptions," and these must be addressed by the teacher in order for the student to alter or replace them with more accurate concepts/theories/etc. The latter concept is critical for teacher candidates to be prepared for relative to the gender gap in science.

Bachtold (2013) proposed three suggestions to enhance science teaching based on these various facets of constructivism. Summarized, they are (a) bring awareness to operative functions of concepts, (b) coordinate teacher and student actions and ideas in order to complete scientific inquiry, and (c) incorporate the study of real science problems throughout history. This means that teachers are critical actors in facilitating student learning, which may seem obvious. Especially critical is a teacher's ability to address student alternative conceptions and provide the opportunity for students really to learn other conceptions in a variety of contexts so as to have a greater chance of replacing the alternative conceptions for the long term. In turn, it provides a basis for inquiry as to how professors of education or teachers are addressing the alternative conceptions that are specifically related to the gender gap.

Just as Bachtold (2013) provided a clear basis for constructivism in science education, Calik, Ayas, and Coll (2010) utilized a modified four-step constructivist model for their research on the effectiveness of teaching methods to promote conceptual change. This four-step approach was defined by Calik et al. (2010) as follows: "(1) eliciting students' pre-existing ideas, (2) focusing on the target concepts, (3) challenging students' ideas, and (4) applying newly constructed ideas to similar situations" (p. 33).

The results of the Calik et al. (2010) quasi-experimental design included a statistically positive difference for conceptual change between the pre- and posttest and no statistical difference between the posttest and delayed posttest. This was interpreted as a positive effect of the four-step constructivist approach toward students' conceptual change, and although it did not eliminate all alternative conceptions, it did reduce them. The thematic analysis of their interview data also supported this positive change.

Constructivism as a theoretical framework for a study on the topic of the gender gap in science, specifically how teacher candidates perceive the gap and how their EPP has prepared them to address it, is well suited due to the nature of how science should be taught as well as how different individuals hold unique perspectives on a single topic. Calik et al.'s 2010 study provides a potential model for teaching science at any grade level. Although the results were not disaggregated by participant gender, elementary students may bring into the classroom with them alternative conceptions relative to any subject. Furthermore, teacher candidates may bring alternative conceptions about science and/or the gender gap into their EPP, which were developed throughout their P–12 education as well as their personal experiences with science. This model does address a technique that has the potential to reduce student alternative conceptions. If used purposefully to eliminate stereotypical gender gap misconceptions, such as all scientists being white males, it may be useful for elementary education teacher candidates.

Although constructivism may very well be applicable to science education or form the basis for research models, as exemplified above, it is important to note its broad relevance to the dissertation topic at hand. Constructivism, a learning theory based upon how experiences lead to learning, is critical in examining teacher candidate perceptions and attitudes about the gender gap in science. It allows the researcher to keep in mind that the data collected from the interviews are an accumulation of the participants' experiences with science throughout their lifetimes as well as the gender gap in science specifically addressed by their EPP. Additionally, constructivism is an important basis for the interviewing of the teacher educators that was done in this case study, as they also bring to the table and into their course curricula their past experiences.

Similar to how different experiences may result in differences in learning, as one would conclude from constructivism, Gardner's multiple intelligences theory delineates differences in learning. Although the focus is not on experiences but on the individual strengths of the learner, if the learner's strengths are identified and utilized, they afford teachers an opportunity to help their students have more successful learning experiences. Adcock (2014) supported the continued importance of using multiple intelligences theories to meet student needs. Adcock (2014) further stated, "The longevity of MI theory, the evidence of effectiveness of MI theory . . . and the literature indicate that using MI theory is effective in meeting the diversity of the learner" (p. 54). Adcock found that a multiple intelligence course taken by K–12 educators was valuable in several ways, but one noteworthy finding was that the course was helpful in them learning how to boost motivation and interest of their students.

If multiple intelligences strategies are employed in the classroom, a true benefit to the teaching and learning process may transpire. Specifically, teachers will have the opportunity to learn their individual student strengths and feed those strengths utilizing the most suitable science teaching strategies they have in their teacher toolboxes, so to speak. It is important not only to investigate teacher candidates' perceptions of gender gap in science but also to investigate what strategies they are equipped with from their EPP in order to concrete their female students' interests in science when they do begin teaching. A question is then, have teacher candidates been prepared by their EPP to utilize learning theories such as multiple intelligences to differentiate instruction for issues such as gender gap in science? Several of the Indiana Department of Education (INDOE) Rules for Educator Preparation and Accountability (REPA) educator standards emphasize the need for teachers to differentiate and individualize instruction according to learner differences. Multiple intelligences theory would be a theoretical foundation through which teachers might reasonably modify their practices. Specifically, the *Elementary Education School Setting Developmental Standards* 2.1, 3.6, 3.8, and 3.14 are relevant. Standard 2.1 acknowledges the importance of elementary educators knowing and applying major learning theories, standard 3.6 acknowledges the importance of differentiating "instruction based on student characteristics and needs and to and adapt lessons to ensure rigorous learning and success for all students." (INDOE, 2010b, p. 4), standard 3.8 acknowledges the importance of "the ability to plan and adapt learner-centered instruction that reflects cultural competency; and is responsive to the characteristics, strengths, experiences, and needs of each student." (INDOE, 2010b, p. 4), and standard 3.14 acknowledges the importance of creating custom learning experiences as a way to meet the needs of individual learners (INDOE, 2010b). Having truly learner-centered instruction based on the characteristics of individual learners is no easy feat, but it may be a solution for engaging and motivating all students in science. The REPA educator standards, as they apply to this study, are discussed further in in the curriculum: educator preparation programs section of this chapter.

Another critical part of the framework of this study is that of feminist theory. Although constructivism and multiple intelligences speak to learning, feminist theory provides a link between the historical oppression of women to continued research on the gender gap in science. It is in connecting the gender gap in science to the field of education, specifically EPPs, that all three theories become necessary. Feminist theory has a rich history of different groups with differing perspectives and yet historically, they hold in common the truth that women's rights should be equal to men's rights. Understanding at least a general history of the beginning of the feminist movement compared to where it stands today awakens us to why closing the gender gap in science is not an easy feat. Josephine Donovan (2000) stated that "throughout the seventeenth and eighteenth centuries – as before and since – the assumption that women belonged in the home as wives and mothers was nearly universal" (p. 19). The enlightenment liberal feminists were one of the first groups to fight for basic women's rights including but not limited to natural rights with a mainstream focus on political rights such as voting (Donovan, 2000). Radical cultural feminist, Charlotte Perkins Gilman, pointed out that women, if freed from their oppression in the home, would be able to utilize their talents to take on paid work and in turn help to end androcentric control (Gilman, 1903). With a sense for the starting point of women working outside of the home in any field, it is clear that from the beginning, they were on a completely different playing field than their male counterparts. The result may be thought of, therefore, as an uphill battle. Jumping forward almost one hundred years, Sharlene Nagy Hesse-Biber and Abigail Brooks (2007) explained that there are women who think that feminists are pointlessly excessive, look stereotypically un-feminine, and are fighting a fight that has already been won. However, the point well made by Hesse-Biber and Brooks is that the level of gender discrimination women may face today is in great part due to the feminist activism that has taken place and is ongoing. With regard to this study, it is important to be prepared for a variety of perspectives about the gender-gap in science, including complete naivety to its presence or more extreme, a denial of its existence.

According to Hesse-Biber and Brooks (2007), with regard to feminist theory and its impact on feminist research, work has been done to challenge the positivist paradigm and improve positivist methods by incorporating the real lived experiences of women. This study, by exploring the perceptions of both female and male elementary education teacher candidates, will seek to understand their experiences and exposure to the gender gap topic. The lived experiences of these teacher candidates should reveal the extent to which awareness of and sensitivity to the gender gap exists, at least for the participants involved.

Perhaps most importantly, according to Jagger and Rothenberg (1993), feminist theory identifies and exposes the subordination of women. Through feminist theory as a first step, action may be designed and implemented to help free women from this subordination. Therefore, according to Flax, feminist theory is not neutral, it is not apolitical, but it is a promise to pursue change (as cited in Jagger & Rothenberg, 1993). In order to make these changes, the oppressive forces that continue to exist must be pointed out and acted against. By answering the questions in this study, it is possible that insight may be gained into both curricular forces and participant lived experiences that maintain the gender gap in science.

Feminist research has evolved from focusing on women as a universal group to focusing on differences among women such as race, ethnicity, class and how these categories play a role in the real lived experiences of these groups of women (Hesse-Biber & Brooks, 2007). Although these differences are important, the small sample size to be utilized in this study will not allow for separation of the participants nor the data into these categories.

Historical Overview and Progress

The gender gap in science is not a new phenomenon, and much progress appears to have been made in the last few decades. In fact, some statistics might lead a reader to conclude that the gender gap has closed in certain areas. For example, even back as far as 1997, women were just as likely to earn a college degree in life science as men. However, this was not the case for mathematics, engineering, physical, or computer sciences (National Center for Education Statistics, 1997).

The gender gap includes factors relative to achievement, attitude and interest, and career aspirations. In 1994, science proficiency scores from the national assessment of educational progress (NAEP) science assessment for nine-year-old male and female students were similar (National Center for Education Statistics, 1997). However, the gender gap in the NAEP proficiency scores, SAT scores, and AP exam scores in mathematics and science becomes more apparent with age, with men scoring higher than women. With regard to attitude, research findings are inconsistent with regard to when the gender gap began to emerge. In 1989–1990, the divergence for science was not apparent until 12th grade, with 60% of male students enjoying science compared to 48% of female students (National Center for Education Statistics, 1997). With regard to career aspirations, a gap appears as early as eighth grade. In 1988, 9% of male students wanted to be scientists or engineers, yet only 3% of female students did (National Center for Education Statistics, 1997).

Today, statistics continue to show prevalence of a gender gap in science in many areas. According to Cunningham and Hoyer (2015), who presented statistics from 2009 on this topic for 12th grade students, 70% of male high school graduates reported that they like science, but only 59% of female high school graduates said the same. In consistency with the National Center for Education Statistics' publication almost two decades prior, Cunningham and Hoyer demonstrated that there was a significant difference between male and female students earning high school credit in different science subjects. Female students earned more credit in advanced biology and chemistry; however, male students earned more credit in physics and engineering. With regard to achievement on the NAEP science assessment, male students scored significantly higher on the advanced biology, chemistry, and physics exams (Cunningham & Hoyer, 2015).

At the least, statistics spanning the last few decades show that although progress in some areas has been made relative to the gender gap in science, much work needs to be done (Haplern et al., 2007; National Center for Education Statistics, 1997). Although the gender gap in science does not seem as apparent at the younger grade levels, it is important to note that much of the statistical data collected on the topic come from the secondary and postsecondary education levels (Cunningham & Hoyer, 2015; National Center for Education Statistics, 1997). Because the literature has mixed results on when the divergence occurs, it is important to start at the beginning, the elementary school grade levels.

Impact of Elementary Educators

Elementary educators likely do not hold a degree in science. Nonetheless, they are tasked with teaching science to our next generation of potential scientists. In fact, such may be true for any discipline that falls onto the curricular plate of the general elementary educator. Payne (1997), who interviewed 30 successful women in physical science and technology, concluded that her participants' interests in science began early. However,

> Sadly, only 13% of the total group recalled positive science experiences in school prior to fourth grade. In order to increase the number of women pursuing careers in physical science and technology, it is important to maintain and/or increase out-of-school science oriented activities and for the most powerful effect, combine them with effective in-school science activities. (Payne, 1997, pp. 101-102)

Payne (1997) also pointed out that the apparent deficiency of schools to stimulate female student interest in physical science and technology may be related to teachers' insecurities about their abilities to teach physical science. She noted that most elementary school teachers have likely not had even a single class in physics in high school nor college. Therefore, elementary teachers need to be trained in physics concepts and in ways that are suitable for hands-on learning for elementary students. Lastly, Payne pointed out the need for science consistency in the curriculum from kindergarten through Grade 12.

According to the U.S. Bureau of Labor and Statistics (2015), close to 97% of pre-school and kindergarten teachers are women, and close to 81% of elementary and middle school teachers are women. This opposite gender gap prevalent in education affords female educators the opportunity to exemplify great science knowledge and skills to their female students. Research conducted by Dee (2006) confirmed that teacher gender does have an impact on student performance, their own perceptions of students, and on their students' engagement with content. Dee (2006) stated, "Simply put, girls have better educational outcomes when taught by women, and boys are better off when taught by men" (p. 71). How might female elementary school teachers take advantage of this dominance in the field relative to the gender gap in science? How might they strengthen their female students' interests and abilities so much in these beginning years that they will withstand the changes in teacher demographics that will occur during their high school and college years where at the secondary level women constitute just 59% of educators and at the postsecondary level women constitute almost 47% of educators (U.S. Bureau of Labor and Statistics, 2015)?

Research by Cotner, Ballen, Brooks, and Moore (2011) also supports the notion that instructor gender matters. These researchers investigated the effects of instructor gender on collegiate student confidence in science ability. They found that female students showed a significant increase in confidence when they had both a female instructor and female teaching assistant, whereas female students who had both a male instructor and male teaching assistant had no change in confidence level. If the impact of instructor gender on student confidence holds true for lower grade levels, then elementary school teachers, being predominately women, may have a window of opportunity, if prepared to do so by their EPP, to impact positively their female students' interest in science.

Educators

Awareness

With regard to gender bias in the classroom, research has uncovered that teachers employ unique behaviors toward their male versus female students. Some examples of these behaviors, noted in a literature review by Erden (2008), who conducted research in Turkey on the topic of gender equity in education, includes the amount of academic contact, assistance versus instructions for independent work (Irvine, 1986), the amount of interaction (Erden, 2008), the level of questions asked, and the consequences for talking out (Sadker & Sadker, 1986). Within each of these examples, female students were at a disadvantage. Specifically, they received less academic contact from their teacher, were provided with more assistance versus instruction to guide their independence during an activity, were interacted with less, were asked easier questions, and were treated worse for speaking out than male students. Due to literature review findings such as these, Erden tested the effect of a gender equity education course on the attitudes of female pre-service early childhood and elementary teachers. Using a pre and posttest analysis, the results of this study concluded that pre-service teachers enrolled in the gender equity course had markedly improved attitudes toward gender issues compared to the pre-service teachers who did not take the course. Lastly, Erden noted that teacher education programs focus on content and pedagogy, but they fail to address gender equity issues. The current study, although employed in a culturally different location, establishes the need to question teacher candidate exposure to gender equity issues, such as the gender gap in science, by their EPP curriculum.

According to the Organization for Economic Co-operation and Development (OECD) 2016 country notes for Turkey and the United States, gender gaps in education and employment continue to persist in both nations. Interestingly though, Turkey has almost a complete balance between women and men graduating from teacher training programs with their 2015 population receiving teacher training at a breakdown of 22% of women and 21% of men compared to the United States population in 2012 receiving teacher training at 19% of women and 6% of men. In Turkey, women graduates of science, mathematics, and computing make up 50% compared to the OECD average of 39%. (OECD, 2017).

With regard to the school culture of Turkey and the United States, a study conducted by Semiha Sahin, which focused on teacher perceptions, found that both countries have positive school culture. According to Sahin (2011), "Turkish schools place more emphasis on teacher collaboration and the U.S. schools put more emphasis on continued improvement and modern teaching" (p. 603). Regardless, the overall positive school culture within both of these countries promotes the academic success of students (Sahin, 2011).

Although gender equity relates directly to this research topic, it must be noted that gender equity lies under a larger social justice umbrella. The conclusions of an autoethnography by Kelly-Jackson (2015) about her journey as a social justice teacher educator enveloped gender as one of a large number of social justice issues that affected her educational journey. As an

African-American, female science teacher educator, she developed and taught a social justice-based science methods course at a large public university. Gender was one of six social justice issues integrated into the curriculum. One finding from this study, which is particularly relevant to this research, is that a teacher educator's lived experiences can impact their teachings as social justice educators (Kelly-Jackson, 2015). Thus, it is not only important to establish an understanding of the perceptions of teacher candidates regarding the gender gap in science but the perceptions of the teacher educators regarding the issue must also be identified.

Research conducted by Carinci (2002), entitled *Gender Equity Training in Selected California Preservice Teacher Preparation Programs*, found that most of the teacher educators whom she interviewed communicated that they did not draw as much attention to gender equity as they should. Data collected via graduate surveys and course syllabi confirmed that gender equity was only addressed minimally and in superficial ways. Carinci (2002) noted that teacher educator interviewees "implied that they would be more cognizant of including the topics in the courses they teach" (p. 109). Recommendations of Carinci include the need for more research on the matter of gender equity in educator preparation programs. By interviewing teacher educators and teacher candidates about the gender gap in science, the research is simultaneously raising awareness of the issue with these interviewees. In turn, their raised awareness may carry over into their teaching.

Attitudes Toward Science

Yilmaz-Tuzun (2008) conducted research to ascertain pre-service teachers' beliefs about science teaching. Through the use of a Beliefs About Teaching scale administered to pre-service teachers at three different universities who were enrolled in a science methods course, it was determined that approximately two-thirds of those surveyed took only one-to-three science content courses. It was also found that there is a positive relationship between the number of science courses taken and the student's confidence using different teaching methods. Additionally, students from this study had greater confidence teaching biology and earth science content over physics and chemistry content. Yilmaz-Tuzun (2008) suggested,

> That science methods courses should encourage students to prepare lesson plans on physics and chemistry concepts…This practice may help those teachers to see their weaknesses and attempt to improve their knowledge of these subjects in their teacher education programs. (pp. 197–198)

Avery and Meyer (2012) conducted a study built upon a literature foundation of the dearth of science teaching happening in elementary schools, caused in part by the low self-confidence of elementary teachers toward teaching science. This study examined how an inquiry-based science course affected the self-efficacy of pre-service teachers toward science and science teaching. This study was built on a theoretical framework that pre-service teachers will have increased comfort with science and likely teach it in their own classrooms if they have experiences that show them they can do science. The results of this study, ascertained from a survey and interview, showed that some pre-service teachers had increased positive self-efficacy after taking the inquiry course, but others did not. However, most pre-service teachers communicated that the exposure to inquiry in the course helped to increase their confidence in science and science teaching. Although neither of the above studies provided all of the answers to increasing the science confidence of elementary teachers, they exemplify that there is room for improvement in this area and offer examples of what may, at least in part, work to address this sub-problem.

Teaching Strategies

Payne (1997) found that her participants' early reading abilities and their reading of science-related materials was very influential to their interests in the subject. Payne emphasized the importance of reading about science and for teachers to provide reading materials that promote student exploration. Additionally, Payne's findings led her to advise elementary and junior high teachers to identify and utilize their female students with high levels of interest in physical science as a way to gather information and promote interest for their other students. Lastly, she advised the use of hands-on activities at all grade levels. Payne's (1997) participants also offered advice to teachers, relative to the teachers' science proficiencies and comfort. Teachers should increase their comfort and competency levels with teaching science, or they should seek out science experts to come into their classroom.

A Turkish study conducted by Hacieminoglu, Yilmaz-Tuzun, and Ertepinar (2009) also supported the usefulness for meaningful learning, which they defined as "when a learner integrates the new idea or concept into his/her existing concepts and structures" (p. 72). These researchers investigated seventh grade students' learning approaches, motivational goals, and achievement in science. Through the use of an achievement test and two questionnaires, Hacieminoglu et al. found that students who achieved high scores on the achievement test preferred meaningful over rote learning. Against stereotypical assumptions, another finding was that female students had higher achievement on the atomic theory science achievement test than the male students. Additionally, students with parents' who had higher educational levels tended to prefer meaningful, over rote learning. This study evidences that at an earlier age, female students may perform just as well with science content as their male counterparts and that those students who achieve higher scores, prefer to learn in ways other than rote learning.

Although the previous studies provided general recommendations for teaching science or teaching science to female students, Haplern et al. (2007) offered five more specific recommendations to encourage girls in math and science. The recommendations in brief are (a) teach students that they can improve their academic ability, (b) give detailed and informative feedback to students on their math and science work, (c) allow female students to be exposed to successful female role models in math and science, (d) "create a classroom environment that sparks initial curiosity and fosters long-term interest in math and science" (Haplern et al., 2007, p. 23), (e) and focus on teaching special skills to female students. Although teaching strategies to combat the gender gap in science are present in the literature, it becomes of interest if they are being taught by EPPs to teacher candidates. If so, then it is of further interest to understand if the teacher candidates prepared to employ them when they get into the classroom.

Becoming even more specific in nature, a teaching strategy tested by Lundin and Jakobson in 2013, and then discussed in a forum contribution by Tank and Coffino (2014), allowed second graders to draw science-related images and then be interviewed about them. Maintaining the advantages of drawing and explaining, Tank and Coffino provided theoretical connections between language and science communication. With regard to understanding science versus science reasoning, the follow-up conversation allows students to share with teachers their rationale for the drawing. During the conversation, it may be found that they know the science concept accurately but drew it differently instead due to a particular reason such as aesthetics or spatial limits. With regard to lexical density of science language, it is lower in verbal form than in written form. This supports the opportunity for conversations to support science learning. Tank and Coffino also noted the importance of learning and using science vocabulary but in a way that is connected to actually doing and communicating science. Lastly, these two combined methods of student drawing and explaining may allow teachers to ascertain student alternative conceptions. This strategy, although not used in the aforementioned research to explicitly address gender gap, may still be a useful tool for elementary teachers to utilize with all of their students, but more specifically with female students who may hold alternate conceptions about who can be a scientist. The tool may also be employed simply as a unique teaching strategy to promote science interest among students.

Addressing female students in a more direct manner may also be a suitable strategy for elementary teachers to combat the gender gap in science. Hardin and Longhurst (2016) measured changes in social cognitive career theory variables of postsecondary introductory chemistry students via a survey. They found that women were at a disadvantage with regard to STEM self-efficacy and interest in STEM and were also at a disadvantage, although lesser, with regard to self-efficacy to overcome barriers. Hardin and Longhurst pointed out the need for interventions in secondary school or earlier in order to alleviate the gender gap in science that continues to be seen at the postsecondary level. Moreover, they pointed out the need overtly to encourage girls to pursue STEM.

By extending this advice to younger grade levels, if elementary educators explicitly address and encourage female elementary students in STEM, it may build self-efficacy at an early age that could persist through their later educational years. By ignoring gender differences at an early age, or supporting what Hardin and Longhurst (2016) described as a null environment, it may be more detrimental to female students than male students.

Curriculum

Elementary Schools

The Indiana Academic Science Standards were revised in 2016 for the kindergarten through 12th grades and were blended into the existing 2016–2017 academic school year standards with full implementation marked for the 2017–2018 academic year. An evaluation committee was composed of Indiana educators, businesspersons, and individuals from higher education. The standards were open for public review in 2015. According to the INDOE (2016), these standards

> reflect the ever-changing science content and the underlying premise that science education should be an inquiry-based, hands-on experience. . . . The Indiana Academic Standards for Science focus on the following topics; physical science; earth and space science; life science; and content-area literacy. For K-8, there are computer science and engineering standards. (p. 1)

Although the science standards for each elementary grade level appear thorough and inclusive of all science areas mentioned above, the INDOE is clear that these standards are not the curriculum in and of themselves, nor do they provide a basis for teaching practices. Taking these disclaimers into mind, interpretation and use of the standards by Indiana educators may be variable.

Additionally, many standards lend themselves to flexibility in their use by the elementary teacher. For example, one of the engineering science standards for third grade is: “3-5.E.1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost” (INDOE, 2016, p. 4). This standard may be addressed in a third grade classroom in a period of 15 minutes or over a semester, depending on the nature of the task to which the elementary educator chooses to attach it. Depending on the pressures that elementary educators are faced with in covering all other subject areas in the curriculum in a typical day, such as reading and writing, the concern is that although the science standards may be used truly to promote a variety of science subjects in an inquiry-based and hands-on fashion, implementation may not match intention. Given the flexibility of their use, EPPs must provide science training to teacher candidates in a way that truly prepares them to know and confidently teach science as well as motivate them to do science consistently with their future classes if participation in STEM is to be encouraged.

Educator Preparation Programs

The study specifically examined courses within the EPP that were likely to address gender gaps in science. Action research performed by Lacueva (2014) in her own university science methods course attempted to examine the impact of integrating theory and practice holistically into her curriculum. Lacueva noted that pedagogical theory is the most valuable theory for teacher education programs. Additionally, teachers need to reflect on many other variables that tie into theory and practice, including economic, social, cultural, political, and historical factors. Seven experiential activities to meet the aim of tying theory and practice together were incorporated into the course: (a) weekly news, (b) book/web page/video, (c) science/technology activity, (d) instrument/kit examination, (e) reflective essays on educational practice, (f) student school project, and (g) class reflections. The descriptive results of Lacueva's study included that students found value in the student school project, fell short on the reflective essays, and did not emphasize reflection very much when they presented their personal experiences teaching science/technology. In all, the study points to a greater need to emphasize theory-practice integration through reflection (Lacueva, 2014).

The idea of connecting theory to practice and relying heavily on reflection to do so means students need to think critically about a great variety of other issues. Within my research, of course, the history of women in science, gender gap in science, and general trends of inequity that can maintain the gap are issues worth addressing. It is one thing to learn methods for teaching science, but it is another to connect these methods to a learning theory or even a social justice theory such as feminist theory, while simultaneously reflecting on the holistic context that external factors play on the science teaching and learning process.

Inquiry-based science teaching is a popularly emphasized method for teaching science. Its emphasis in an EPP's curriculum would not be surprising. However, a qualitative case study conducted by Villa and Baptiste (2014), which was built upon a socio-culture learning theory, addressed a disconnect between the acknowledgement of the effectiveness of teaching science via inquiry from its actual employment. The purpose of the Villa and Baptiste investigation was to study the learning development of a single pre-service teacher with regard to inquiry pedagogy. The specific connection to Vygotsky's theory focuses on the idea that students learn through social and cultural experiences that allow them to interpret phenomena, possibly through investigation. This theory, integrated into methods courses, means a shift from teacher-centered to student-centered learning must occur. After implementing a five-part inquiry-based pedagogical approach into both math and science methods courses, Villa and Baptiste found that prior conceptions about traditional learning were indeed transformed to reflect a true understanding and implementation of inquiry-based pedagogy. As the EPP's curriculum was analyzed for information relative to the gender gap in science, inquiry based teaching methods and practice were sought as ways that may potentially benefit female student interest in science. These methods exemplify a type of tool that pre-service teachers may or may not be equipped with by their EPP.

Indiana approved EPPs are expected to adhere to the INDOE licensing rules. According to the INDOE (2018), as stated on the REPA Educator Standards page of their website, “All programs must align to a content area as well as appropriate developmental/pedagogy standards.” (p. 1). The REPA educator standards that are most relevant to the EPP and target population of this study are the *Elementary Generalist Standard 5: Science* and the standard five sub standards, as well as the *Elementary Education School Setting Developmental Standards* 1 through 6. Among other items, according to the elementary generalist standard 5, elementary educators are expected to have a full understanding/ability to deliver instruction about/using: scientific inquiry, science processes, ethical aspects of science, scientific investigations, multisensory exploration, science methods, problem solving, physical science, earth and space science, life science, and engineering and technology (INDOE, 2010a). Although these standards are not the curriculum per se, they should be utilized within the curriculum of the EPP so that elementary education teacher candidates are prepared to use, design, and teach science that incorporates all of these topics, methods, and science subjects. Although the intention of this study was not to check for the presence or absence of this science standard in the curriculum, it is important to note that elementary generalist science standard 5 envelops topics and methods that are relevant to elementary student interest, motivation, and achievement. Additionally, standard 5.2, in part, speaks to the importance of addressing ethical aspects of science, and the topic of the gender gap in science is just one of many examples that could be addressed with regard to science ethics. The INDOE elementary education school setting developmental standards also envelop an array of topics that are relevant to this study. For example, standard 1.4 addresses knowledge of student diversity including gender; standard 2.3 addresses knowledge of the importance of hands-on experiences and the development of problem solving skills; standard 2.5 addresses “knowledge of how student learning is influenced by different types of instructional practices and teacher behaviors, and the ability to use this knowledge to promote learning for all students.” (INDOE, 2010b, p. 3); standard 3.9 addresses the importance of providing learning experiences that increase students’ global awareness and in turn stimulate their interests in solving global problems; standard 3.12 addresses the importance of finding and using appropriate resources to accommodate differentiated learning; standard 3.14 addresses the importance of incorporating real-world issues, realistic problem solving, and global awareness; standard 3.16 addresses the importance of knowing what may enhance or weaken student engagement and the application of strategies that promote the engagement and motivation of students; and standard 5.1 addresses the importance of “. . . supportive, and inclusive learning environments . . . that encourage all students’ engagement, collaboration, and sense of belonging.” (INDOE, 2010b, p. 6). Gender as an aspect of student diversity and addressing global problems both speak to the topic of the gender gap in science. Hands-on experiences, problem solving, the use of appropriate instructional practices to motivate and engage students, and providing a supportive, encouraging learning environment all speak to ways that elementary teachers can promote student interest in science.

Need for the Study

Research that specifically discusses whether the science gender gap is addressed in EPPs or how teacher candidates perceive it has not been found. There is an abundance of literature that provides statistics on the gender gap in science at the secondary and post-secondary levels as well as work-force related statistics. There is also literature available relevant to teacher candidates' comfort, or lack thereof, with science. The results of this exploratory case study partially fill a deficit in the literature by tying together theoretical constructs and research on the gender gap in science with research about teacher candidates' perception of the problem and how the curriculum of their respective EPP addresses the problem. As instructors of the biggest pipeline for potential future female scientists, it is critical to understand not only their perceptions toward the gender gap but also their exposure to the topic in their EPP. This study also identifies specific teaching strategies that are being used by the EPP that, once employed by the new elementary school teachers, have the potential to increase female student interest in science.

Summary

In this literature review, three major categories pertinent to the study emerged: an overview of the gender gap in science, educators, and curriculum. Within the overview of the gender gap in science, a theoretical framework relevant to science education and the research topic was unveiled, which incorporates constructivism, feminism, and multiple intelligences. Feminist theory and its ties to the foundation of the topic of this study were identified, a brief historical overview of the gender gap in science as well as some of the progress that has been made toward closing the gap was described, and the impact that elementary educators may have on the problem was highlighted. Within this first category, constructivism serves as not only the theory that ties very commonly to science teaching but also to how the data in this study, specifically the teacher candidate interview data, were products of constructivism from both their personal and academic life experiences. In a sense, constructivism was the filter through which the data were gathered. Although some statistics show that progress has been made in some areas of the gender gap in science, the problem still persists at large, and elementary educators may be a key group in impacting female student attitudes toward science.

The second category delved further into the connection between the gender gap in science and educators. Educator awareness of the problem may be low due to the lack of focus on gender bias in their program and their attitudes toward science may be negative in part due to a lack of science coursework in their educational careers. Teaching strategies that may be useful to them in closing the gap were present in both general and specific recommendations within the literature, but it is unknown as to whether these recommendations were presented to teacher candidates by their EPPs.

The third category, curriculum, was broken down into elementary schools and EPPs. Indiana science standards for elementary grade levels were examined, and although they appear thorough for a variety of science subjects, there is no required amount of time or type of lesson by which these standards are to be covered by elementary educators. With regard to the EPP curriculum, connecting theory to learning is critical, but with regard to this study, the implementation of feminist theory is especially imperative. Without it, teacher candidates are missing a lens through which they might otherwise recognize the gender gap in science as a problem. This is a critical first step if they are to make a positive impact on the problem within their own classrooms. Also related to the EPP curriculum and the multiple intelligences theory, the INDOE REPA educator standards were examined.

CHAPTER 3

METHODS

The purpose of this qualitative exploratory case study was to investigate elementary education teacher candidates' perceptions toward the gender gap in science, their attitudes and senses of responsibility toward closing it, and their potential strategies to encourage female student interest in science. Second, it was to investigate teacher candidates' exposure to the topic of the gender gap in science from the EPP in which they are enrolled, including a variety of artifacts and their teacher educators' shared perceptions on the topic. These two facets, being directly linked to the field of elementary education, fill a niche in the literature relevant to the gender gap in science as detailed in chapter two. Thus, the significance of this study is that it adds to the research base on the gender gap in science, focusing on the perceptions that new teachers will bring with them into the elementary classroom. As instructors of the biggest pipeline for potential future female scientists, it is critical to understand not only their perceptions toward the gender gap but also their exposure to the topic in their EPP. This study not only garnered perceptions; it also identified specific teaching strategies that are being used by the EPP that, once employed by the new elementary school teachers, have the potential to increase female student interest in science.

Research Questions

1. What perceptions do elementary education teacher candidates hold relative to the gender gap in science?
2. What perceptions do elementary education teacher candidates hold relative to their responsibilities in closing the gender gap in science?
3. What perceptions do elementary education teacher candidates hold about taking on responsibilities toward closing the gender gap in science?
4. What ideas/strategies do elementary education teacher candidates possess that may afford them the opportunity to engage female student interest in science?
5. How does the curriculum of the EPP address the gender gap in science?
6. What perceptions do teacher educators at the EPP hold relative to the gender gap in science that they share with their elementary education majors?

Qualitative Research

The above research questions lent themselves to qualitative research methodology. This exploratory study examined a small case within a university in Indiana to establish an understanding of how a particular problem relative to both science and education is perceived by two different stakeholder groups as well as examine how the EPP curriculum addresses the problem. With the information sought, no attempt was made to determine any particular cause and effect, but the aim was to provide a holistic picture of the case, relative to the gender gap in science.

Paradigm

The research questions relate to many concepts tied to the social constructivist and feminist paradigms and were therefore developed through a hybrid paradigmatic lens. To exemplify the multiple realities view of both of these paradigms, every participant in this study had varying life and curricular experiences shaping their attitudes toward the gender gap in science, even though they were all a part of the same EPP. This multiple realities perspective as well as valuing of the teacher candidates and teacher educator perceptions toward the gender gap allowed for conclusions to be well-rounded and open to unique views.

A concept in line with the feminist paradigm is that of female self-identity, according to the environments they are situated in (Hesse-Biber, 2006). The academic settings and experiences of female students relative to science may do more than just influence their attitudes toward the subject, such may also impact their attitudes about themselves and what it means to be a woman in today's society.

According to Hesse-Biber (2006), "Feminist research begins with questioning and critiquing androcentric bias within the disciplines, challenging traditional researchers to include gender as a category of analysis" (p. 5). In the natural sciences, there is common knowledge of androcentric bias radiating throughout history. The sheer number of male scientists versus female scientists recognized for major contributions to the field within a student's science books throughout their K–12 education provides them this common knowledge. In seeking to understand the experiences of teacher candidates relative to the gender gap in science, I acknowledged that gender still matters while being simultaneously aware that even within a single gender, important differences exist and should not be ignored.

The theoretical origin of the multiple realities ontological viewpoint is rooted in philosophy and falls at the opposite end of the spectrum for the ontological views in quantitative research. The social constructivism paradigm is rooted in sociology and the principle that reality is a construction formed from understanding the experiences of others over conversations between those participating in a study and the researcher. Also having a multiple realities viewpoint, the theoretical origin of the feminist paradigm is rooted in the philosophy of power and identity of oppressed groups (Creswell, 2007). Another notable relationship between these two paradigms is that of historical realism and modern relativism (Guba & Lincoln, 2005). In advance of collecting data, I recognized that a co-construction of realities between my participants' experiences and my interpretations of their stories would be unconsciously enveloped by an androcentric history that has laid the foundation for their current situations. Although progressive feminists and resilient female scientists have made cracks in this foundation, it has not been completely broken and therefore has an impact on today's elementary educators, teacher educators, and elementary students, even if unbeknownst to them.

Approach

A case study as defined by Stake, "is not a methodological choice but a choice of what is to be studied." (Denzin & Lincoln, 2011, p. 443). By explicitly identifying that this study took an exploratory case study approach, I hope to emphasize that what has been learned from this study is special to this case. Additionally, this approach allowed two important steps to unfold: a general investigation into the case itself and an examination of the outcome of the investigation (Denzin & Lincoln, 2011). A case study as defined by Bogdan and Biklen, is "a detailed examination of one setting." (Bogdan & Biklen, 2007, p. 59). However, only after the choice was made as to what would be studied, could the detailed examination launch.

The personal interview was utilized as a primary vehicle to gather information from participants, both elementary education teacher candidates and elementary teacher educators. According to Bogdan and Biklen (2007), interviews conducted within qualitative research form a unique product. Interviews

> may be the dominant strategy for data collection, or they may be employed in conjunction with participant observation, document analysis, or other techniques. In all of these situations, the interview is used to gather descriptive data in the subjects' own words so that the researcher can develop insights on how subjects interpret some piece of the world. (Bogdan & Biklen, 2007, p. 103)

Although interviewing was the dominant strategy for data collection in this case study, document analysis was utilized in conjunction with interviewing so as to examine the case from multiple angles.

Methodological Preparation

A course-based inquiry project conducted for the purposes of methodological preparation to investigate the topic of personal and academic experiences that shape female science majors' attitudes toward science and nature allowed me to more clearly understand and refine several of the methods I used in this research. Through these invaluable experiences, I worked with four female undergraduate science majors who volunteered to help with the understanding that this was a course-based inquiry project. I used their interactions to better understand facets of the development and refinement of a personal interview protocol on a similar topic. These individuals also allowed me to practice the administration of an interview protocol, which helped shape my understanding and practice of establishing rapport with research participants. Moreover, within the parameters of this course-based inquiry project, I was able to understand issues associated with and practice the maintenance of data confidentiality, open and axial coding, and the analysis of the categories that emerged from the data.

From these practice interviews, initial codes were developed upon completing the line-by-line coding process. From these initial codes, 15 categories were developed. The initial coding suggested that there is a wide array of factors that may influence, in either direction, a female student's inclination toward nature or science and that there are a multitude of experiences that may occur in a variety of settings relative to nature or science. With such a large variety of influential factors and types of experiences, the complexity of the data I hoped to review in my main study was apparent.

The wide array of codes and information collected in this course-based inquiry project, therefore, prepared me for analyzing the interview data from the main study on a spectrum, both contextually and with regard to participant perception. This served as a reminder that the interview data carried out in the main study is a mixture of not only what the elementary education teacher candidates are being taught about the gender gap from their EPP, but a mixture of former personal and academic experiences about the topic. It should be emphasized that the participants in the course-based inquiry project were science majors, and the participants in the main study were elementary education majors. Nonetheless, the main study afforded the opportunity for teacher candidates to share their perceptions on the gender gap in science and quite possibly shine a light on the potential impact they will have on their future students.

Design of the Study

The study design focused around three elements of the case: teacher candidate perceptions of the gender gap in science, teacher educator perceptions of the gender gap in science, and how the EPP curriculum addresses gender gap in science. Data were collected on these elements via personal interviews, and data about the curriculum was also obtained from course syllabi and textbooks.

Assumptions and Limitations

It is assumed that the teacher candidates' perceptions toward the gender gap in science were shared in full during the interview process, that they included the influence of the current EPP they are enrolled in, and that they will carry these perceptions with them into their classrooms. The limitations in this exploratory case study include narrow transferability due to the small sample and the single institution utilized. Additionally, data collected from the teacher candidate interviews were not fully reflective of the influence of the EPP. Rather, it was likely a reflection of the EPP mixed with former personal and academic experiences. Science and gender were both generally addressed. Science was addressed as any subject or process that investigates the natural world, and gender ignored other influencing demographic factors such as race and ethnicity. The data collected from the teacher educator interviews, as well as the written curriculum, were limited to the perceptions of those selected for the interviews as well as the artifacts utilized to gather data.

Teacher Candidate Interview Protocol

The teacher candidate interview protocol (see Appendix A) for the teacher candidate participants was developed uniquely for this study but is based upon the research questions as well as the interview protocol developed from my course-based inquiry project. The protocol document served as a tool to collect primary information such as the interview time, date, location, interviewer and interviewee names, and position of the interviewee. Additionally, it served as a guide for the interviewer. It contains an explicit step for the administration of informed consent followed by 13 interview questions and 16 probes. The interview questions within this protocol served to build rapport with the interviewees, address research questions one through four, and also provide information relevant to research question five.

Teacher Educator Interview Protocol

The teacher educator interview protocol (see Appendix B) for the teacher educator participants was developed unique for this study but is based upon the research questions as well as the interview protocol developed from my course-based inquiry project. The protocol document served as a tool to collect primary information such as the interview time, date, location, interviewer and interviewee names, and position of the interviewee. Additionally, it served as a guide for the interviewer. It contains an explicit step for the administration of informed consent followed by 13 interview questions and 13 probes. The interview questions within this protocol served to build rapport with the interviewee and address research questions five and six.

Curriculum Analysis Protocol

A curriculum-mapping table (see Appendix C) was utilized to record the various pieces of information collected from the syllabi and textbook artifacts of the courses analyzed in this study. The data were categorized based upon a specific link to either the topic of the gender gap in science or teaching strategies associated with teaching science in elementary schools as supported by the literature review. The curriculum-mapping table, adopted in consultation with my committee, was modified to fit the topic and needs of this study. The curriculum analysis protocol served to address research question five.

Setting and Participants

Participants were selected from a public, regionally accredited university in Indiana with an elementary EPP. Five elementary education majors in their final two years of the program and five teacher educators who lead instruction for elementary education courses were interviewed in a location on campus that was convenient and comfortable for the participants and that allowed for the maintenance of confidentiality. Three courses, called Course A, Course B, and Course C, provided data for the curriculum element and were selected for analysis based upon the teacher educator participants selected for the study.

Data Collection and Analysis

Data collection for this case study was three-fold, and thus, data triangulation was achieved. The teacher candidate interview data, the teacher educator interview data, and the curriculum analysis data constituted the three aspects of the case and provided a basis for how the gender gap in science was being perceived by these individuals as well as being addressed by the curriculum. Specifically, comparing the responses of the teacher candidate interview responses and the teacher educator interview responses shed light on the presence of similarities and inconsistencies between these two groups relative to gender gap in science perceptions and how the problem was being addressed by the EPP. A comparison between the teacher candidate interview responses and the curriculum analysis data as well as between the teacher educator interview responses and the curriculum analysis data served the same purpose.

Interview Data

For all interviews, two recording devices were used, one digital audio recorder and one audio recorder phone app, in order to ensure that the conversation was recorded for subsequent transcription. At each appointment, a small amount of time was used to meet and greet with the interviewee with the motivation being to establish comfort for both the interviewee and myself before delving into the interview. Reflective writing in the form of memos was carried out immediately after each interview concluded as a way to record personal reactions to the interviews. The memos were used as a springboard for my subsequent interpretation of the data.

The interview audio files were thoroughly and confidentially transcribed verbatim by a hired transcriptionist into word documents. Pseudonyms were established for all participants, as well as those individuals they discussed, to ensure anonymity of both groups. Verbatim in nature, in addition to the main questions and responses of each interview, the transcriptions included filler words and non-word responses of the participants and myself as the interviewer. This type of detailed transcription allowed me to obtain as much information as possible from each participant.

After all of the interviews were transcribed, coding steps common to many qualitative approaches were employed to analyze the interview data. First, open, line-by-line coding with the interviews was completed, and then with a fluid coding frame established, axial coding of all interview transcripts followed. The coding process allowed for connections between codes to be established and for the development of categories to transpire. Theme development between categories was recognized and described narratively.

Curriculum Data

The curriculum data, recorded via the curriculum-mapping table, were analyzed for the amount and variety of ways that the gender gap in science is addressed by the syllabus and textbook. The ways in which the gender gap was addressed included specific links to either the topic of the gender gap in science or teaching strategies associated with teaching science in elementary schools as supported by the literature review. Additionally, the curriculum data were cross-referenced with the teacher educator interview data as a way to illustrate a relationship between the information shared by the teacher educators via personal interview alongside the information found within their syllabi and textbooks for the courses.

Ethical/Human Participants Concern

In qualitative research, ethical considerations are a common thread throughout the entire research process. Rapport and trust between my participants and myself was critical in pursuing open communication throughout the personal interviews. According to Christians (2005), four categories have been traditionally put forth by professional associations into their ethical codes: informed consent, deception, privacy and confidentiality, and accuracy. A consent to participate in research was read to and signed by each participant before the interview started.

Enveloped explicitly in this consent form was the ethical concern of confidentiality. The participants were made aware that their full names will be left out of the transcripts and that the transcript would only be read by my committee sponsor and myself. Participants were also made aware that a transcriptionist would transcribe the audio files. To promote further privacy and confidentiality, pseudonyms were employed in the findings section. With regard to deception, this was avoided in advance of the interview and directly before the start of each interview where the topic, the reasoning for my research, the program that I am enrolled in, and my interest in the topic were offered to the participants. My effort in letting the participants know that they are just that, participants, was done with the intention of being overt about the qualitative process as well as curb any power differentials that may have been at play between my interviewees and myself. With regard to accuracy, nothing from the audio tapings was left out of the interview transcriptions, and my interpretations were made from a co-construction of the data in these transcriptions, acknowledgement of my personal experiences and biases, as well as recognition that there are a multitude of routes that a researcher may have taken in interpreting the data.

Researcher Background

Growing up, I was interested, and still am interested, in science. For my undergraduate degree, I majored in biology and minored in chemistry, and although being a science major in college was not always easy, my attitude toward the subject and my self-confidence in being able to graduate as a science major were strong enough to endure the more stressful courses. I played outside much of the time growing up; I enjoyed visiting state parks; I enjoyed school in general, and I worked hard in school; I attended a small, women's college, was raised by a very independent single mother who was involved in my education, and I had many great teachers throughout my educational career who motivated and challenged me (some specifically told me I should take more science). During college, I worked for a summer as an interpretive naturalist at Turkey Run State Park. After college, I worked as a high school biology teacher for seven years. Many of my high school students disliked science before they stepped foot into my classroom. I always wondered why they were already so disinterested. This is a short list of just some of the experiences that have shaped my attitude toward nature and science and my interest in pursuing research on the gender gap in science. I am aware that my life experiences are unique from the experiences of others and wonder if any of the above puzzle pieces had not been in place, would I still have a passion for science or would I have still majored in biology, worked as an interpretive naturalist, or worked as a biology teacher? By being cognizant of the importance for self-reflection in order to overtly present my biases and secure them when necessary, I consider myself a well-suited researcher for the topic. Given my current and past work experiences in the field of education, I was similar enough to my participants to connect with them on the topic even though our dissimilarities were extremely significant.

Institutional Review Board

As with all human participants research, the details of this proposal along with all instruments utilized in the study were submitted to the Indiana State University's Institutional Review Board (IRB) in February of 2018. After an expedited review, on March 2, 2018, the IRB granted approval of the study to begin.

Summary

In this chapter, the methods used in this study were described. Six research questions were formulated to investigate the perception of elementary education teacher candidates toward the gender gap in science as well as their exposure to the topic from their EPP. The study was designed to be qualitative in nature, and therefore, a paradigm and approach were formulated that suit the topic. The paradigm is a mixture of social constructivism and feminist theory, and the approach is case study with personal interviews being a major instrument utilized to collect data. A course-based inquiry project conducted by the researcher was summarized to exemplify the prior use of the methods within a related topic as well as show how data collected from personal interviews is a yield of social constructivism.

To summarize the design of the study, three instruments were designed and used to collect information from participants and the written curriculum. A personal interview protocol for the teacher candidates, as well as a personal interview protocol for the teacher educators, was utilized. Additionally, a curriculum analysis protocol with a data collection table was employed to analyze the written curriculum artifacts. Five elementary education majors in their final two years of the program and five teacher educators were interviewed from a public, regionally accredited university in Indiana. Course A, Course B, and Course C from the EPP were selected because they were courses taught to elementary education majors by the teacher educator participants. Syllabi and textbooks from these courses were analyzed.

Data triangulation was achieved via analysis of three data sets. These data sets included the personal interview data of the teacher candidates, the personal interview data of the teacher educators, and the curriculum analysis data. The interviews were recorded, transcribed, and then coded to establish categories and themes. The curriculum data were analyzed for the amount and variety of connections made to both the gender gap in science as well as the interview data.

Ethical concerns remained at the forefront of this study. All efforts were made to establish trust and rapport with the participants of the case study, and anonymity was and will be maintained. Due to the qualitative nature of the study, the researcher background and potential biases have been shared in an effort to maintain transparency. Approval from the IRB at Indiana State University was granted before any data collection for this study began.

CHAPTER 4

RESULTS

Participants' Background and Demographic Information

Of the 10 participants of this study, five were traditional elementary education teacher candidates. Abigail, Annie, Cayden, Diana, and Natalie were all traditional elementary education majors in their last two years of the program. Abigail was a female, senior, elementary education major with a minor in special education. She was on track to graduate at the traditional four-year mark but transferred two years of coursework from a community college into the institution that this case study explored. Therefore, Abigail was in her second year of coursework at the institution. Annie was a female, senior, elementary education major with a minor in special education reading and was on track to graduate early from the institution after three and a half years. Cayden was a male, senior, elementary education major with a minor in reading and was on track to graduate after five years at the institution. He changed his major from music education in his third year. Natalie was a female, senior, elementary education major with a minor in reading and was on track to graduate after four and a half years at the institution. Diana was a female, junior, elementary education major with a minor in reading and was in her third year at the institution.

Of the 10 participants of this study, five were teacher educators. Dr. Knight, Mr. Lewis, Dr. Rogers, Dr. Rosenberg, and Dr. Zigler were all instructors of at least one course that elementary education majors might take within the EPP. Courses A and B were science content courses and Course C was a science methods course, all of which were offered to elementary education majors. Dr. Knight was a female professor who taught Course A. Mr. Lewis was a male instructor who taught Course B and Course C. Dr. Rogers was a male associate professor who taught Course A. Dr. Rosenberg was a female associate professor who taught Course C. Dr. Zigler was a male associate professor who taught Course A.

Elementary Education Teacher Candidate Participants' Background and Demographic Information

Influences of home, academics, and influential persons. An understanding of the science backgrounds of the elementary education teacher candidate participants was constructed from information they shared related to their home experiences, academic experiences including the types of science and science activities they have encountered, and a number of influential people. Only one participant, Diana, shared at-home science experiences, and both of her parents were science teachers. Despite some very young at-home science, which she enjoyed, her soon-to-come negative school science experiences solidified her dislike of science. Diana stated,

> I had the fun side of science at home with the exciting things that I would do, and then when I would go into the classroom, it was a lot of textbook and stuff, so I feel like that kind of scared me away from liking science.

With the exception of Cayden, who had family members who were teachers and advocates for education in general, other participants shared things regarding home lives. For instance, Annie offered that hers was "not an academic family." Abigail suggested that there was a lack of science conversation in her home (despite being a farming family). Overall, elementary education teacher candidate participants shared very little science influence from friends and family. They shared experiences from primarily school settings, which included many science subjects, science activities, science tools, and science activities, but science was not discussed as a process. Biology, advanced placement biology, chemistry, physical education/health, earth and space science, integrated chemistry and physics, were some of the high school and college courses mentioned. Only one participant, Cayden, shared an experience of taking an advanced science course, which was high school advanced placement biology. Despite a teacher who yelled at him, which he felt was a dissatisfying experience, the science activity in the class was joyful and the rigorous curriculum he deemed much harder than any required science he had taken since at the college level, thus providing him relief as a college student. Regarding his advanced placement high school biology experience, Cayden said,

> I think it definitely set a new standard for me because it was a lot more difficult than a lot of my college classes, so at least it gave me that fresh breath where I got into college, and I'm like, “oh cool, I don't have to do all of this.”

Another participant, Natalie, shared her dissatisfaction with not being prompted by her high school guidance counselor to take anything harder than integrated chemistry and physics. Making the decision to take the easier science class had a negative impact on her. Natalie said, “She (guidance counselor) didn’t even try to tell me, ‘Oh, you should try chemistry and challenge yourself’; she just let me choose that (integrated chemistry and physics).” Participants discussed a wide array of influential people in their lives with regard to science, including teachers of all levels (elementary, middle school, high school, and college), cooperating teachers, parents, guidance counselors, and friends.

Science exposure in past and present contexts. Past and present contexts shed light on the science exposure and experiences of junior and senior elementary education majors. As noted in the introduction to the candidates, all teacher candidate participants were majoring in elementary education with four of five participants being seniors in the program and one being a junior in the program. Interestingly, the seniors were at different years into the program because one had transferred from another institution, and others were graduating sooner or later than the typical four years. Also, some participants had minors including reading and special education reading. Despite being almost complete with their undergraduate program, memories from many levels of education were shared during the interviews.

Their personal elementary, middle school, high school, and collegiate experiences were discussed, as well as experiences from their elementary clinical experience placements. Within this latter category, a common theme that emerged among participants was a lack of science teaching being observed in the classrooms of their current clinical experience placements. With regard to their pre-student teaching internship program experiences, the elementary education teacher candidate participants shared their takeaways relative to the consistency and amount of time they had observed science teaching.

At her first grade placement, Abigail observed what she described as consistent science teaching but defined this as one to two times per week for 25–30 minutes each. Abigail also described that science as a subject splits time with social studies and health, so it competes with these other subjects. Abigail noted, “I wouldn’t say every day that they are doing it, but at least maybe once or twice a week, I do see the teacher. They alternate between science and social studies and health.” Cayden suggested that there is a lack of time for science teaching, but that on average, he had observed 30 minutes being spent on science, one to two times per week at his placement site. He also expressed sympathy for his cooperating teacher when he said, "She's an excellent teacher, so I just feel bad that there's not more time because there, there's a lot that needs to be done for reading, writing, and math." Annie also expressed the lack of time for science and that she had not observed any science for seven consecutive weeks within her kindergarten placement. Annie said, "I'm on my seventh week, and we haven't done science once. We just, we haven't had time, we also have a ton of behavior problems, so we're lucky if we get much of anything done." Diana shared that she had observed 30 minutes of daily science teaching at her placement site but that it was mostly out of the book. Diana stated,

> She teaches it every day, but a lot of it is out of the book. I've seen them do like a couple of activities, but there's 30 minutes for science and at least an hour for everything else, so I feel like she tries to focus on getting it in.

Natalie said, "They don't do it often" and described this as once per week for about 20 minutes with regard to her observations at her third grade placement site.

Limited science exposure and experiences. Overall, exposure to science and experience doing science among the elementary education teacher candidate participants was very limited in past and present experiences. Teacher candidate participants could recall some science experiences from a variety of their P–12 school experiences, as well as experiences at the undergraduate college level. With the exception of Diana, who did some at-home science with her parents when she was very young, the elementary education teacher candidate participants did not share memories of science experiences outside of the traditional school setting. With the exception of Cayden, who took advanced placement biology in high school, and Abigail, who had participated in the middle school science fair, the participants recollected science memories from what may be gathered as science courses that meet the minimum science requirements of their high school and college programs. Based on participant reflections on school experiences, they have not only seen a lack of science within their clinical experiences but Cayden also mentioned a lack of meaningful science exposure at the university level. He stated,

> Honestly, there's not a lot of academic stuff here at the (institution) that I've seen too much of that did much for science to give me any viewpoint that is different than what is already, besides life science, I guess, but that is more of my personal investments in health.

Elementary education teacher candidates mentioned that they have had little-to-no opportunity to teach science to elementary students so far in the program. According to Diana, "I've taught it (science) occasionally," and when asked if she had taught it yet for her pre-student teaching internship, she said, "Not yet. I teach that in two weeks." And when Cayden was asked the same question, he stated, "That's next week." As Annie, who had not observed any science at her placement for seven weeks, put it,

> I'm doing my science lesson in like two or three weeks, I think, and so I know that my kids are going to get at least four days of science that week, so that has put a lot of pressure on me because I'm like, "I want to make these really good and memorable for the kids, and I want to do something fun, and we're not even going to look at the workbook because that's not fun."

Little memory of in-school elementary science experience was shared by some elementary education teacher candidates such as Annie who explained, "Like when I was in elementary school, we didn't do science a lot." and Diana who shared, "Let's see, I don't remember a lot of science . . . I think I most remember doing in like kindergarten and first grade, nature walks and that kind of thing and finding things outside and doing projects with that."

Feelings about science. Although participants were able to recollect both joyful engagements with science as well as science experiences that were dissatisfying, only one elementary education teacher candidate participant, who happened to be the only male, expressly stated that he liked science. In response to the question, *Do you like science?*, the female participant responses were negative or neutral. Abigail stated, “I guess, but growing up I didn't.” Annie said, “I think science is cool, but I don't understand it.” Diana just replied, “Sometimes.” And Natalie very clearly informed, “I wish I did, but I don’t.” Cayden, again the only male elementary education teacher candidate participant answered, “Yes, Yeah, I do.”

Factors that relate to dislike of science. Passive learning and ill-mannered teachers from their education were factors related to elementary education teacher candidate participants’ dislike of science. Elementary education teacher candidate participants shared dissatisfaction with science experiences that involved primarily watching and listening, listening to lectures, taking quizzes, note-taking, looking at pictures from the book, reading, and completing worksheets. Participants also attributed their dissatisfaction with science to a lack of hands-on activities and experimentation. As Abigail noted,

> I feel like sometimes I wasn’t much of a listener-learner; I was very much a hands-on learner, and I feel like in science, it was a lot of listening for me growing up, so I just never really liked it, I just, I hated science. All I did was sit there and take notes and listen to the teacher. It was always take notes and listen, watch this experiment on the computer or look at this picture in the book of this experiment. We never actually got to do it.

Annie had similar feelings on the issue and said, “We did it maybe two days a week, and when we did it, it was like reading from the book and filling out a worksheet, and it was never anything fun." Diana reflected on her middle school science experience with some of the same sentiment,

> When I was in middle school, I had teachers that, instead of doing activities or experiments, we really just wrote from the book and did worksheets and maybe did like one or two experiments the whole year, but it was mostly from the book, and I just feel like that wasn't exciting.

Diana went on to speak more generally about her dissatisfaction with science when she said, "I feel like science can be really exciting, and sometimes you spend so much time lecturing about it and focusing on the details, that it makes it less exciting." These comments speak to the fact that some participants thought science was boring.

The other major piece to their dissatisfaction seemed to stem from teacher dispositions and actions. All elementary education teacher candidates shared about at least one teacher from their past who influenced them negatively. Diana commented about her high school physics teacher: "He didn't care about students and making us like science. He liked science, but he didn't care about if we liked it or not." Furthermore, Natalie made this comment regarding her fifth grade teacher: "She told our class that we were dumber than a box of rocks." Other distasteful elements as identified by the participants to have been displayed by instructors encompassed lack of civility including anger and yelling, lack of clear instruction including the withholding of explanations or additional instructional support, lack of motivational support including withholding of encouragement or leniency where effort was displayed, and lack of psychological support including instructor actions that promoted feelings of being personally disliked or misunderstood. With regard to lack of support, Abigail noted,

> I had a chemistry teacher in my hometown, at my hometown college, and he never showed up, and he just expected all of us to learn it on our own and know how to use the tools and everything on our own, and we weren't ready for that yet.

With regard to rudeness and lack of leniency, Annie mentioned an experience taking biology online over the summer. "My professor didn't have any leeway, and he was really rude, and every time I tried, he was like, 'This is inadequate.' He always said that. 'Inadequate. Inadequate.'" Cayden expressed his feelings about a high school science teacher as, "My teacher was just a [pause]; she was just a bad lady to me. She just yelled a lot which was kind of annoying."

Factors that relate to fondness of science. Experiments, real-life connections, and supportive teachers were factors related to the elementary education teacher candidate participants' fondness of science. Elementary education teacher candidate participants shared many factors that relate to their fondness of science, which included doing experiments, doing science with their clinical experience elementary students, experiencing the science methods curriculum, watching science demonstrations, observing nature, taking the science laboratory class, completing projects, doing at-home experiments, and experiencing enjoyment due to personal interest in the topic, science with real-life connections, and discussion. Abigail held fond memories of participating in the eighth grade science fair. She stated,

> We had to research a topic on our own and go out and do it, and it wasn't super in-depth science, but I remember really breaking it down, and I loved going out and interacting with people . . . and I loved to create the board and then share it with others.

Cayden also reflected on early science experiments that were hands-on in nature. He really emphasized that his interest was high because of the real-life connections that were made. Cayden said,

> Second grade we used a wet cloth with the plant, and we put it inside. We kept it nice and wet all week. We got to see the seed start, have roots come out along with putting plants in soil and watching them grow. Uh, fourth grade we stayed a bit more on chemicals. We were doing solids, gasses, and liquids, which I really got into because it's something we see every day, so it was very, very relevant.

Abigail shared her excitement in doing science within her pre-student teaching internship,

> Doing science with my first graders at the school that I'm at, I really enjoy it . . . talking about planting a seed and then actually plant the seed and watch the plant grow; like that's really exciting because I like to see how they interact with it and then bounce ideas back and forth to them. I think that's a lot of fun.

Annie shared her positive experience with the curriculum of Course C, which was the science methods course: "We do all kinds of experiments, and [instructor] shows us stuff that the kids would like at all different grade levels, so that's been kind of fun, doing all those things." Annie went on to say that the Course C curriculum helped her in "realizing that science can be fun, no matter if I'm doing it for kindergarten or fifth grade."

They reflected positively on certain teacher traits. Those teacher traits were being attentive to student enjoyment, providing ideas, being supportive, and breaking down the information. Natalie described her fourth grade teacher as her role model when she answered who had positively impacted her attitude toward science. She explained,

> Probably my fourth grade teacher. That was the one where we did the shoeboxes that I can remember, and he did a lot of interactive things; I remember that, and he's the reason I want to be a teacher, so I just have like a lot of positive memories from him.

Abigail had positive things to say of her eighth grade science teacher: "My eighth grade science teacher, whenever we were doing the science fair project, she really made sure that we did something that we enjoyed. She was right there for everyone." Diana shared positive comments with regard to her high school biology teacher: "She made me excited about it, about learning. I think that she really liked science and that made us all excited to learn about science." Diana also reflected fondly on a Course C experience:

> [Instructor] sent me home with a box of circuits and a book, and I figured out how to build them myself, and I had fun with it because it was something that I didn't think that I could do and then as I was building it; I was surprised when I turned the light on, and I was really excited about that and then excited to show my class.

Annie spoke fondly about her Course C instructor,

> With that professor that I have, [instructor] . . . like, "Science is important. Science is important." I'm always going to remember that and be like, "Science is important" because when I don't want to do science, I'm going to be like, "Science is important. These kids need science."

These comments spoke to not only instructor support and encouragement but also to student understanding and the positive feelings that transpired upon success.

Fitness, confidence, preparedness, and comfort. The science fitness of the elementary education teacher candidate participants, their confidence in science, and their feelings of preparedness for elementary science teaching were mostly low, but their comfort with elementary science teaching was variable. Participants shared past experiences in science in which they felt inadequate, lacked comprehension, and struggled. Overall, they are not confident. Natalie stated,

> Even if I plan ahead, I still feel scared teaching science and feel like I'm not good enough to teach it or that I'm not knowledgeable enough, but I hope I can encourage all the students to think they can be good at science.

Due to an experience with an online college science instructor, one participant even felt so torn down that she gave up and cheated in a class. Fitness factors such as care, drive, and effort, however, may be helpful in overcoming feelings of ineptness.

Confidence in science, although low, was figuratively self-medicated by participants via their intentions to rely on science they have already seen or done and to read, review, and prepare for science in advance of teaching lessons. As Abigail shared, “I review the material that I’m going to be teaching, like right before I teach it, but to just ask me a question; I’m not probably going to recall it.” Abigail went on to say, “If I was just thrown into a classroom, I would have to probably do an experiment that I’ve already done or base something off what I’ve already done.” Cayden noted that confidence varied based upon the science subject and personal interest in the subtopic. Annie noted that she felt confident with teaching at the elementary level, just not the science. With regard to preparedness, teacher candidates shared that they felt unprepared. Cayden attributed this to not having knowledge of the full elementary science curriculum and standards yet. Diana noted that although she felt unprepared, being enrolled in the science methods course of the EPP was helping. With regard to preparedness, Natalie stated, “I think I'd be ok teaching it (science) because you can find fun experiments and stuff online but I don't, I still feel unsure about it.”

Some teacher candidate participants had matching levels of discomfort in elementary science teaching to their confidence and their preparedness; others felt more comfortable than confident or prepared. With regard to the comfort of teaching science at the elementary level, this variability among participant responses was noted via the following quotes from most to least comfortable. Abigail and Cayden both expressed that they felt pretty comfortable with regard to science teaching. Abigail said, “Well, I feel like I’m pretty comfortable . . . maybe on a scale of one to 10, I would be a six or seven.” Abigail also remembered an experience in which she felt uncomfortable using science equipment during a college chemistry course. She said, “We had seen, like the tools and materials before, but I, a lot of us weren’t comfortable using them without him (instructor) being in the classroom watching us, showing us how to use them exactly.” Cayden not only expressed being pretty comfortable with science teaching but provided reasoning relative to the flexibility of the process of science. He said,

> Uh, I feel pretty comfortable, I’d say. I like the idea of students learning how to observe and get higher levels of thinking, so I think that could also partially be more of an emotional type of thing because you can gauge their interests at that point, and failure isn’t always bad in science because it is just a new discovery, so it’s just taking it a different way, maybe not to the success but just a roundabout path, so I feel pretty comfortable with that because in math, if you get the problem wrong, I mean it’s just wrong, but in science you can now observe an entirely new process that’s about to happen, like the lifecycle of a butterfly.

A little less confident than Abigail and Cayden, Annie stated,

> I'm comfortable with the teaching part. I think you get, if somebody gave me a textbook and said "Teach this," I could do it. I would just [pause], I would have to look over it before and kind of figure out everything.

Diana expressed that she has not only discomfort but fear with regard to science teaching. She stated, "Probably not very comfortable. Um, I've taught it occasionally, and I would say that it is one of my subjects that I'm most worried about." Natalie also felt discomfort with regard to science teaching and stated concisely, "I'm really not very comfortable at all."

Although comfort levels varied among participants, it is important to note that some participants still had not had the opportunity to teach a science lesson at the elementary level. Comfort for some participants was dependent on grade level, where lower grade levels afforded them more comfort. As Annie described, "Right now I'm at the kindergarten level, so it's not too difficult, the science, but if I was in fifth grade, I would be very scared." Abigail noted that the idea of her future young audience being oblivious to the accuracy of the teacher was comforting in that,

> I just have to remember that even if I say something wrong, they don't know either, so if I say something wrong, they're not going to come down my throat, but I do need to correct myself if I catch it.

Treatment with regard to gender identification. Two of five teacher candidate participants experienced a time when they felt their gender identification set them apart for the worse. Three participants did not specifically recall or share a time when their gender identification set them apart for the better or the worse. Two participants did. Both had experienced bias from a teacher. One male and one female participant claimed to have experienced bias. In the words of Cayden,

> Yeah, I feel like, uh, individuals probably thought as a male I would think more logically and I would grasp it a lot more quickly or I would be more invested in it, while females may need more explaining because it might not pertain to them quite as much.

In turn, this had a negative impact on him because the teacher did not check in on him as much. Natalie's fifth grade experience in her own words: "She (teacher) had us split girls and boys, and then was giving the girls different ideas than the boys for our science experiments, and it seemed like ours had to be easier, like simpler ideas." Natalie also shared,

> Boys my age always just talk down to me during science or math, and that's just always made me mad; like even boys now . . . they still act like they're the best like math and science teachers ever and like always like still imply it, and so I think it's more, this might be sexist to say, I don't know, but I think it is more males that make us feel like we're not good at science or math, like tell us this until we just think it.

Teacher Educator Participants' Background and Demographic Information

Influences of home, academics, and influential persons. An understanding of the science backgrounds of the teacher educator participants was constructed from information they shared related to their home experiences, academic experiences at different levels of education including the types of science and science activities they have encountered, motivational experiences, and a number of influential people. Four out of five teacher educators shared recollections of positive experiences from their childhood in which they spent time exploring the outdoors. From exploring nearby woods and streams to fishing, camping, mushroom hunting, and rock collecting, they were engaged with nature from a young age. As Mr. Lewis described, "And of course, I grew up without computers, cell phones, and my parents took me fishing and camping and mushroom hunting, so I was out." Dr. Rogers also grew up camping, which he attributed to being from a poor family but said, “Family vacations, maybe we went camping. I liked being outside and doing outdoor things.” Dr. Rogers also described,

> I liked being out playing in dirt or doing things outside with my friends. We would periodically go take the dogs to some stream behind my parents’ house where there was a woods, and I would go walking around in there, and I always liked those sorts of environments when I was a kid.

Dr. Knight reflected, “I used to steal rocks out of people’s yards and then break them open.” Dr. Zigler reminisced on time spent outdoors with his family when he said, “Walking around with my mom and my siblings in the woods, you know, all afternoon, looking at, trying to identify different types of rock.” Some teacher educator participants also mentioned having or desiring science materials at their disposal at home such as a telescope, science reading material, chemistry set, microscope, and kitchen materials. Some felt supported by their parents and families with regard to science, yet others felt as if they were discouraged by them. Dr. Knight reflected on both her desire for science materials and being discouraged by her parents when she shared, “Probably starting from when I could read, I asked for a chemistry set and a microscope set, and my parents always told me ‘No.’ So my parents always discouraged me from being a scientist.” Mr. Lewis, on the other hand, felt very supported by his parents and reflected, “My parents bought me a telescope. Hours and hours I would sit out there, so you know, space became a whole avenue for me.” Mr. Lewis also had an aunt who encouraged him in science and he shared that, “We’d go to the bookstore, and she would buy me books on nature.”

Their P–12 academic experiences were variable, yet each was afforded unique science opportunities. Examples include that Dr. Zigler was homeschooled until the age of 16 and enthusiastically began studying earth space science at approximately six years old from an advanced textbook. Dr. Knight completed an entire year of chemistry in fifth grade and an entire year of physics in sixth grade. Mr. Lewis was greatly influenced by the launching of Sputnik, and later as a senior in high school, he won the international science fair. Dr. Rosenberg selected the science and engineering curriculum track in high school, and Dr. Rogers worked as an unofficial teacher's assistant in high school biology. Though not all of their P–12 academic science or science-related experiences were memorable or positive, such that some recollected having poor high school science teachers or having a hatred for math, the positive P–12 science experiences that they did have seemed to have a great impact on their interests in science. The fifth and sixth grade school science experiences of Dr. Knight especially stand out in the data. She described,

> Beginning in fifth grade, I had my first chemistry class, so it was entire year of just chemistry which I think is pretty unusual. And then in my sixth grade year, we had an entire year of physics. And so the experiments that I did in fifth grade were exactly as the ones I did in college except that it was all about observation, and there were no calculations that we had to do because we just didn't have the math skills yet.

At the undergraduate and graduate levels, the teacher educator participants shared recollections of both good and bad experiences with science and about their choices to major in science or science education. These conversations made it clear that science teachers do not equal scientists. When reflecting on the lack of support she received from her family, Dr. Knight shared,

> When I said I was going to be a scientist, they were like, "Oh, you're going to be a science teacher?" I was like, "No, I'm going to be a scientist." "Ok, you are going to be a science teacher," right?

Dr. Rosenberg also made a distinction between being a scientist and a science teacher when she said, “When I started college, I wanted to study and become a chemistry professor but maybe my college learning, college experience was not very energetic . . . so I just decided to be a teacher.” The personal and academic experiences relative to science that participants shared opened up numerous science or science-related topics, which demonstrated their wide array of science exposure and expertise as well as their longevities in the field.

Although some teacher educator participants shared memories of being discouraged by teachers, parents, family, or friends, all shared that they received encouragement from one or more individuals. From official mentors to suppliers of general encouragement, middle school teachers, high school teachers, college advisors and instructors were mentioned, but no elementary school teachers. Dr. Rogers commented, “I had a really good biology teacher in high school who encouraged and challenged me. I think that has really had a positive influence on me.” Dr. Knight shared, “I think I’ve had really good mentors all of my life. Um, I had a great chemistry teacher when I was in high school who really encouraged me to be a chemistry major in college.” Dr. Zigler stated, “I was encouraged by a faculty member to basically apply for a research experience for undergraduates program, and as part of that, I had to go present my end of the research season findings.” Outside of the academic setting, parents, spouses, siblings, neighbors, friends, colleagues, and even famous scientists were means of encouragement.

The motivational elements of the teacher educator participants took many forms. Some forms were extrinsic experiences such as Dr. Zigler receiving encouragement from a neighbor that segued into an international trip to meet a famous scientist who happened to be female. Extrinsic experiences also included being challenged by high school and college instructors and being heavily recruited by administrators at various schools. Some forms were intrinsically based such as being captivated by the subject, having increased interest in a topic with personal usefulness, pursuing excellence, and finding happiness. Dr. Rogers reflected on working in science as a means to happiness when he said, “I think that it’s not about money for me; it’s about I do what I want, and I ask questions I want, and I feel like I’m kind of good at it so, uh, I’m happy with where I am and what I do.” He also said with regard to usefulness, “I feel like if it’s something that’s useful for me; I suddenly become a lot more interested in how it works.”

All of the teacher educator participants had additional titles in their lives, such as mom, dad, aunt, nature photographer, space enthusiast, minister, and law school student. Their experiences in most of these additional roles overlapped with their role as a college instructor of science or science education. For example, four teacher educator participants who shared that they were parents talked about doing science with their children at home and/or for their children in an academic setting–from bug collections and species identification to formal presentations in their classrooms. Another teacher educator detailed her role as a science mentor in her nephew’s life. As a minister, one teacher educator participant noted his work as a science tutor for members of his congregation. Dr. Rogers described his constant engagement with science as well as his science-related hobby that he shared with his daughter:

> We’ll go on a bug hunt together. She’ll find some bug, and then I’ll take a picture of the bug with a macro lens so I can clearly see what it is, and then I will spend hours trying to figure out what the bug is, and then I will work with her to explain what that bug does and what’s interesting about it, so I’m always engaged in it, even if it isn’t in the classroom.

Degrees, rank, titles, and courses taught. The degrees, rank, titles, and courses taught at the institution provided context for the influence they had on elementary education teacher candidates. By rank, the teacher educator participants included an instructor, three associate professors, and one professor. Their undergraduate and graduate degrees were in geology, geography, biology and chemistry education, and science education. The courses taught by these teacher educator participants that were optional or required for elementary education teacher candidates to take in their program were Course A (optional), an environmental science course; Course B (optional), a chemistry and physics science course; and Course C (required), a science methods course. Course B and Course C were designed specifically for elementary education majors; however, Course A was an option for elementary education majors to fulfill their required science credits.

Passion and fitness. All of the teacher educator participants were passionate about science and/or teaching. Although they have had both good and bad experiences relevant to science and/or teaching, they collectively possessed a wide array of traits (see table 1) that exemplified extreme fitness to be working as scientists/science educators. These traits may be beneficial for elementary education teacher candidates to learn, work on in themselves, and recognize and foster in their students. When asked the simple question, “Do you like science?” all teacher educator participants wholeheartedly expressed their passion for science. In the words of Dr. Rogers, “Yeah . . . probably a bit too much.” Or as Dr. Zigler put it, “Oh, yeah. Of Course!” Mr. Lewis was especially enthusiastic in his response, “Oh, do I love science?!” Dr. Rosenberg joked, “Sure. That's why I teach science, right?” And Dr. Knight explained, “I do like science. I love science. I always have. I've always wanted to be a scientist.”

Factors relevant to the teacher educator participants’ fondness of science included positive P–12 and postsecondary experiences with good advisors, teachers, good professors, good science experiences such as labs, encouragement, challenges, and research experience all being discussed. Mr. Lewis shared about the support he received from one of his P–12 science teachers when he said, “My seventh grade science teacher got me interested in doing science projects when I was in the seventh grade, and then when I was a senior, he took me to the international science fair.” Dr. Rogers reflected on a positive high school biology experience with a teacher who challenged him. Dr. Rogers explained,

> I liked collecting the bugs, but then when we would do the test part, I would get every question correct, and all of my classmates would get less than half of them correct, you know? I would basically take time from what I was doing, once I realized they didn’t understand something. I would quickly figure out what the things were, and then I would spend the rest of my time in the class basically showing everybody else how to do it. I was like the teacher’s assistant, basically . . . the teacher then knew that I always knew all the answers, and so when I would get tested, he would make my test harder.

Another positive academic experience for Dr. Rogers came during his undergraduate experience when he was approached by instructors who asked if he intended to become a geology major. He shared,

> I took all these geology classes and did well on all of them . . . and then like two years into taking all the classes, they pulled me out of one of the classes and were like, “Are you thinking about becoming a geology major?” and I was like “I hadn’t until you just asked me but that seems like a good idea.”

With regard to encouragement from professors in general, Dr. Rogers shared, “Professors at the graduate and undergraduate level that pushed me to, to believe in myself or to believe in what I could do and had really high expectations of me.” With regard to the positive impact of putting knowledge into practice while doing field work, Dr. Rogers reflected on his undergraduate field experience. He said, "That field camp experience for me really crystalized what it was and my confidence in myself, going out and trying to do the things." Dr. Zigler discussed the positive impact that his undergraduate and graduate advisors had on him:

> I had an undergraduate advisor who basically was like, "Hey, have you ever thought about doing a thesis, an undergraduate thesis?" I was like, "Well, yeah, but how do you do that?" He was like, "Well, you just ask me," right? So having those people that kind of lead you down the right path has been pretty great, and then my, my Master's and Ph.D. advisor, and all of his students, we're all like a, kind of like a family.

They also shared positive experiences within their current positions, which included research, teaching, summer science camp participation, working with graduate students, and observing elementary education teacher candidates in clinical experiences. With regard to teaching, Dr. Zigler reflected on the joy he'd experienced teaching his students just earlier in the day of that interview:

> I mean, today, actually. Teaching in (Course A) and we were talking about the difference between the Cassandra view point and the Cornucopian, and this is usually how I end the class . . . We had some fun conversation about it. Um, it was great!"

Dr. Knight expressed the pride she felt for her current graduate students:

> So right now I have two graduate students who are really phenomenal, and they are so excited about their projects and what they can do with their data; it's just infectious. I'm really proud of what they've accomplished and how they are approaching their projects, and it is exciting to work with them because they are so excited.

Mr. Lewis also expressed pride for his students, specifically the students of Course C when he said,

> I went out to observe my (Course C pre-student teaching internship) students and watching them teach children, and it was just absolutely phenomenal . . . children become so excited when they're learning science, and I went home and I told my wife, I just saw some of the greatest teaching.

Factors relevant to the teacher educator participants' dislike of science included negative P–12 and postsecondary experiences. They discussed bad math experiences, bad teachers, bad professors, negative college science experiences, lack of support, and gender bias. Dr. Zigler reflected on his struggles with mathematics that persisted for 15 years. He described,

> I would do math with my dad in the evening . . . and I struggled with math, and when you have somebody who's intuitive in a discipline like that, they don't understand when it's not intuitive for you. Math is a fundamental part of science, and for me, it was an unpleasant experience and probably took 15 years to fix. I hated math until I finally took statistics twice. I did it fine the first time; I just took it again because I was like, you know, I scored well on the exams and stuff, but I don't understand this.

Dr. Rogers reflected on a negative experience with a bad science teacher that impacted him through college:

> In high school, I had a teacher who taught us physics but wasn't really that interested in teaching or physics, apparently, and when I took the class and I had a question about something that I didn't understand, he would just tell us to read the book, and he did all sorts of things that I think are very bad practices. He would just give us the tests and then turn on a video camera and take a nap in the back of the class. He wasn't a very good teacher, obviously, and he was also our chemistry teacher, and for that reason, I feel like

> all the time when I dealt with chemistry when I was coming through college, uh, it was challenging, more challenging than it should have been relative to other things that I do.

Generally speaking, Dr. Zigler also shared that he had bad experiences with college instructors: "I had some instructors who were not very helpful or would blame me for things that I clearly saw as a deficiency on their part."

They also shared negative experiences within their current positions or former teaching position(s), including issues with administration, too large of classes, lack of funding, lack of equipment, peer review, missteps in teaching, and gender bias. Frustrations were expressed by one teacher educator participant whose class size for Course C is being doubled. It was stated,

> "I have 12 people in my (Course C pre-student teaching internship), and that's all I can handle. Because by the time you let each of them do lessons, get equipment out for them, you've reached your max. They're putting 25 (into the class).

Dr. Zigler commented on peer review and missteps in teaching when he stated, "Peer review can be dissatisfying . . . in the classroom there's got to be one a week where it's just like, 'aw', you know, I just tried to explain speciation and evolution and that didn't go the way I planned, right?"

A wide array of traits and actions were shared by teacher educator participants, which supported their fitness/success in the field of science/science education. Although this list, presented in Table 1, is unique to the teacher educator participants who were interviewed and their life experiences, this list of traits could serve as a resource for elementary education teacher candidates to reflect upon with regard to success in science.

Table 1

Traits and Actions that Influence Science Fitness Shared by Teacher Educator Participants

Fitness	Codes
Traits	Ability, adaptability, adaptations to ruthlessness, attitude, care (for subject), competitive, confidence, courage (to ask for help), curiosity, dedicated, determined, driven, ease, effort, energetic, exceptional ability, exceptional skill, fascination, focused, genetically suited to abstract logic, good comprehension, high achieving, interest, intuitive, leader, likes to learn, motivated, passionate, perseverance, persistence, process-oriented, responsibility, speed, strengths - experiential learning experience, support network*, trustworthy, understanding, visual learner
Actions	Ask for help, collaborate, don't give up, pushback on peers' comments, have a plan B, sacrifice (be willing to),
*	". . . knowing that that support network is there and participating in it is . . . pretty important for understanding how important science can be for society and also . . . realizing that network of support needs to extend downward. It can't just be Ph.D.s looking out for each other and that's something we don't do very well in the university system, I think." – Dr. Zigler

Treatment with regard to gender identification. Four out of five teacher educator participants divulged a minimum of one experience in which they felt that their gender identification set them apart for the worse. Only the male teacher educator participants shared that they had experienced times when their gender identification set them apart for the better. Experiences of gender discrimination in which the two female teacher educator participants felt that their gender identities set them apart for the worse included general feelings of being judged as well as specific missed opportunities or bias. Dr. Knight shared much on this topic. She stated,

> I feel that as a scientist, people have treated me differently through my career. I don't think I noticed it as much until I came to (institution), where other, like colleagues treated me differently, I felt, because I was a woman.

Dr. Knight also shared that becoming a mother has increased the gender bias that she has experienced where others have shifted their expectations of her in a belief that being a mother inhibits the ability to be a scientist. In her words, “When I first got here, I think that people really expected a lot of me as a new professor, and then their expectations decreased every time I had a child.” Dr. Knight felt that college instructors had lower expectations of she and her fellow female science majors, and she described, “I had a lot of experiences where people told us we didn't belong or we were encouraged to do something different in terms of our majors or there were just lower expectations of us generally.” She also pointed out that her students assumed that her title was Mrs. rather than Dr. in her current position: “There is a perception even of our students regardless of their major that the female faculty aren't at the same level as the male faculty.” Dr. Knight also experienced times when she felt that her expertise was questioned due to her gender. When asked to stop a project, she pushed back and in the end was successful in completing her project. She described this experience: “If I had been male, they might have tried to get me to stop the project, but I don't think they would have said, ‘Are you doing things correctly?’” She also stated,

> I feel like I've been bullied by the administration because they didn't want me to do certain projects because they were afraid of how it would reflect on the (institution), but I've always pushed back against those things, and I've always succeeded.

With regard to conducting research in the field, Dr. Knight expressed concerns about safety. She said, “There have been times when I was in the field that I felt less safe than if I had been male, but in general as a scientist, I don't feel like I'm different." Dr. Rosenberg reflected on an experience in which she learned that she was completely overlooked for an open teaching position due to her gender. Dr. Rosenberg said, "I was in one high school and then the vice president told me, 'I wanted to recommend you but the school principal . . . wanted a male teacher.'"

A few experiences of gender discrimination in which male teacher educator participants felt that their gender identities set them apart for the worse were shared. Dr. Rogers expressed that being a white male today was a disadvantage because one must be exceptional as a white male trying to get a spot in a predominately white male community. In the words of Dr. Rogers,

> Most faculty in the geosciences field, is older white male components. They are all looking to diversify, and so I feel like it would probably be easier for me to get a job someplace had I been something that was more diverse than I am.

He went on to say, "I feel like I inherited part of that problem because the science was so white-male dominated that it, and in some ways still is; it's challenging for people who are white and male to compete." Dr. Zigler expressed that being a male scientist has meant his decisions have been blamed on his gender. Dr. Zigler described, "My decisions have been cast as male decisions in the postmortem and it's like, 'No, I did it for this reason,' but you can call it a male deci . . . you know, you can be like, 'oh, that would be, that's a typical male decision' if you want." Dr. Zigler also recollected times when he was called names by angry female colleagues and not by male colleagues.

Although the male teacher educator participants acknowledged that the problems they faced with regard to gender identification were different from those faced by their female counterparts, they also shared experiences in which their gender gave them advantages.

Experiences in which male teacher educator participants felt that their gender identities set them apart for the better, including facing less discrimination, were shared. Dr. Zigler described it generally when he said, “Yeah, I mean, I think it has been both ways, but overall being male has been an, is definitely an advantage in science.” Dr. Rogers put it, “I don't deal with the same problems that women in science probably experience. In that sense, I have an advantage.” Dr. Rogers also shared a memory of a college class he took in which the professor was blatantly misogynistic. He noted that although all of the students supported one another, he was at an advantage because the environment was simply less hostile because he was male. With regard to field work, Dr. Zigler shared some advantages of being a male scientist. He shared that perseverance won him permissions with research participants but did not work as well for his female colleague. He stated,

> Well in fieldwork, being male is a positive most of the time, and I’m sure it sets me up for success over my female colleagues, and I’ve seen it in action, actually. I’ve been in the field on a project where I was kind of providing logistic support on another project and . . . I would almost always get the interview if I was perseverant enough, uh, . . . it would take her three, four times and sometimes it just wouldn’t even happen to get permission to do those same things.

And in general, he noted that males were at lower risk of violence in remote field locations, and therefore, he felt more confident in his safety. Dr. Zigler also noted experiences in which he admitted to talking over female colleagues in the room but self-corrected once he realized what he had done:

> It's way easier for me to talk over a woman than for a woman to talk over a man in a meeting, and so that means that if I'm going to push to get my point heard, I can do it

> over a female colleague most time, not universally true, and the person running the meeting is more likely to inadvertently allow me to talk over the person who was ahead of me because I'm male and they're female. I mean that happens, and I've watched it happen.

Respect was easily gained from male students by Mr. Lewis who described, “Being a male, I think I was respected by the male students that I had. Matter of fact, I was a baseball coach for 18 years.”

Perceptions of the Gender Gap in Science and Responsibilities

Elementary Education Teacher Candidates’ Perceptions of the Gender Gap in Science, Responsibilities of Teachers, and Personal Responsibilities

Knowledge of the problem and responsibility. Elementary education teacher candidate participants had varying levels of understanding and varying levels of confidence in their understanding of the gender gap in science but thought of it as a problem that could be addressed, and although there were things that teachers could do to take on this responsibility, taking on the responsibility personally stirred up doubt. Nonetheless, certain motivational factors were present for them to do so. The elementary education teacher candidate participants’ knowledge of the gender gap in science ranged from nonexistent to having a general idea of the issue. When asked what the gender gap in science is, Annie stated, “I have no idea.” She went on to say,

> Science is like my least (favorite) of all subjects. I'm not very good at science. I never have been, so I've never really been interested in it, but I imagine that people who really are feel like there is a gap. When you think of a scientist, you think of a male, and I can

> see how some women could be really frustrated with that, just like when you think of a teacher, you think of a woman, not a male.

Moving a little further over on the spectrum, Natalie asked, “Like, I think there are more males involved in science than females?” and Diana said, “Well, I would say there are definitely a lot more males than females in science.” And pushing a little further toward a surface comprehension of the topic, participant knowledge of the existence of certain stereotypes and misconceptions were shared, such as the idea that women are not smart enough or do not care, that the first thought of a scientist is a male, that men are logical and women are emotional and since science is logical, it is thus male oriented. As Natalie said,

> I think we all get told when we're younger, like boys are so good at math and like girls are so good at English, and so we just kind of brush off our females, and I think if I was told I could try to be good at science, I would have put more effort, but usually I ask boys for help because I thought boys knew how to do it.

Responsibility of teachers. Elementary education teacher candidate participants felt that there was a responsibility of teachers to address the problem and that indeed, it was a problem that could be addressed. They offered many suggestions in light of acknowledging the responsibility of teachers. Though participant knowledge on the gender gap in science was limited, they thought that in general, it was a problem that could be addressed. With the exception of one participant who was unsure if the gender gap in science existed, others ranged from not knowing if the problem can be addressed to expressing the need for more information. One participant noted that this study might be helpful. Parents, teachers, society viewpoints, changes in generation mindsets, and specifically, math and science camps for girls were mentioned in light of addressing the problem. Despite the participant responses being limited and similar on whether it is a problem that can be addressed, they became more detailed with regard to the responsibilities a teacher may have with regard to closing the gender gap in science. Their ideas for teachers included introducing the gender gap in science to elementary students, reading about gender gaps in science, letting students know that change is possible (gender gap can close), helping all students understand that science is important, and letting students know that, as Annie said, "If they want to grow up to be a scientist, they can be a scientist." Cayden focused specifically on the need for teachers to stop gendering items, to dismiss gender labels, and to turn off gender stereotypes. Cayden stated, "Students have started saying, 'That's a girl book' or, you know, 'That's girlie' or something when, in truth, it's just information." Cayden also suggested that the teacher provide information about acceptable paths and communicate that it is okay to read and do things that are not mainstream. As Cayden expressed it, "That is a teacher's responsibility, to make that moral judgement of is it ok to let them know that it's acceptable what they can and cannot do." Diana suggested teacher responsibility may come in via communication with students: "If you talk more about women scientists then maybe that would, like help a little bit." They noted that it is important to show students that science is not only for men and to explicitly encourage girls. As Natalie advised, "Just encouraging the girls that they can be good at science, too, and involving them in it." In general, promoting interest in science, showing that science is fun, and providing support for science were thought to be important by the participants. And advice that might lie most heavily on elementary teachers comes from Natalie who stated, "Teachers starting off when we're younger, they just try to involve everyone more in science."

Personal responsibility. Elementary education teacher candidates acknowledged that the gender gap in science was a problem that could be addressed by teachers; however, they felt personally less responsible and/or that taking on the responsibility was intimidating. Despite sharing these rather specific and insightful teacher responsibilities for closing the gender gap in science, when asked about their feelings of taking on the responsibility of closing the gender gap in science themselves, there seemed to be a shift in mindset. Annie did not feel a responsibility to work on the problem because she needed permission and shared that one needs science knowledge to effectively affect the gender gap in science. In her words, “I don't know much about science, so I don't really feel a responsibility.” Other participants reacted to taking on the responsibility with words describing such a task as “daunting” as lamented by Diana, and a “tall order” according to Cayden. In full, Diana said, “I feel like it's maybe daunting. I don't know, but I also think that it's important, and it's something that I would like to do.” Despite participant doubts, some offered details about how they might take on the responsibility. These included that although there are some things you cannot prepare for, getting to know students well, making real life connections, adapting lessons to student backgrounds, building student self-esteem, and helping them to see the beauty and the bigger picture may be helpful. As Cayden said, “It is just getting students to understand how it can be used, I think, in their daily life.” Although only one participant truly seemed to like science, motivation for helping to take on the responsibility in closing the gender gap in science might come from their future new roles as teachers. Motivational factors expressed by participants included that it was a second chance for science and a chance to break the cycle (of their negative experiences with very little science). Additionally, participants expressed that motivation stemmed from being a female teacher and learning that science is important. With regard to being motivated by her own gender, Diana stated, “I mean, being a female teacher, definitely I want my students to be excited and realize that they are capable of doing anything no matter what their gender is.”

Teacher Educators' Perceptions of the Gender Gap in Science, Capabilities of the Educator Preparation Program, and Personal Responsibilities

Thoughts about elementary education majors. Based upon their teaching experiences, teacher educator participants shared strong thoughts about their elementary education teacher candidates and science as well as their habits of supporting and encouraging their elementary education teacher candidates. The teacher educator participants shared a variety of thoughts about their elementary education teacher candidates and science. Collectively, these painted a very similar picture to what was shared by the majority of the elementary education teacher candidate participants of this study relative to their dislike of science. Lack of preparation and knowledge, low confidence and motivation, low enthusiasm, and a fear of science were all described. When reflecting on current elementary education teacher candidate students, Mr. Lewis said, "They haven't taken enough classes to bring their knowledge in science up to where it should be." Dr. Rosenberg said,

> They (elementary education majors) say, "I don't like science. I'm not confident." And they're kind of a little bit less motivated, right? So that's why I try to do more hands-on activities because if they enjoy my class, they enjoy their teaching, too. So our students actually go to school for three weeks, and then they actually teach the minimum three lessons, and so after that, yeah, they are excited in teaching science, and they tell me, "I can teach science in my future classroom." So, that's actually my goal of teaching (Course C).

Dr. Knight expressed a similar opinion:

> My experience with elementary education majors is that they are not enthusiastic about science at all, and they just want to know what they have to do to get out of the class, but

> they're not particularly interested in learning the science, which I think is a little bit unfortunate because a lot of the things that we do in [course A] could actually be applied to an elementary education class. They don't see that link.

Mr. Lewis spoke about the fear of elementary education majors,

> When I first started teaching elementary education, I found out that 95% of the students in my class had a fear of science and a fear of me and a fear of the course I was going to teach, basically because of the lack of knowledge.

However, he noted that elementary education teacher candidates showed appreciation for his team approach to teaching and learning.

The teacher educator participants expressed their tendencies to offer support and encouragement to their students. They described this as happening via real talk, providing individualized support for students, being flexible with student schedules, having a personal desire for their students to be successful, and discussing/offering advice to students about study habits and effort. Examples of real talk from Dr. Zigler to his elementary education majors were "Most good things take a lot of work so I do emphasize that," and "You're gonna have to work in this class, not because you're you but because this content is more challenging for you than for others." An example of real talk from Mr. Lewis was "I've always encouraged every student that I've had, male or female, 'get as much math as you can get because if you get the math down, the rest of it's easy.'" Having a personal desire for their elementary education majors to be successful was wholeheartedly expressed by Mr. Lewis and Dr. Rosenberg. Mr. Lewis described,

> “Failure is not an option on my watch” . . . in my syllabus I put that in there. Failure is not an option on my watch, and I tell my students, “You're not going to fail. I will not let you. I do everything I can.”

He also shared, “I tell my students that this is my purpose, to get you interested in science.” And along the same sentiment, Dr. Rosenberg stated, “I just want them to like science and then to be confident in teaching science.” An example of providing individualized support for an elementary education major came from Mr. Lewis who said to a student,

> “Okay, I'll just sit down and get you started” and you know, I sit down with her, and she could not thank me enough. And I said, “That's why we're here. That's why we're here.” And she got it all done, and she felt good.

An additional example of going above and beyond for students included Mr. Lewis, in reference to his role as a clinical supervisor and his decision to observe his students more often than required, who stated, “I don't see how you can do your job right and not go to see them once a week. Because if you go every other week, if a problem comes up, it may be too late to save them.” Mr. Lewis and other teacher educator participants had a history of going above and beyond as an educator or scientist. Mr. Lewis once took approximately 12 students to the international science fair; he switched jobs and took a significant salary cut in order to fill a much needed science position at another school, and he assigned and has mentored students in a variety of science projects and field trips beyond the requirements of the curriculum and outside of the traditional classroom setting. Dr. Rosenberg reflected on her participation in a teacher organization as a relatively new secondary science teacher and her development of science activities and lessons within the organization. Dr. Knight reflected on her middle school science experiences and her desire to do as much science as possible: “There were enough labs that we could do a new lab every single day. And so I got through the entire book because I wanted to do all of the labs."

Impact on P–12. Teacher educator participants shared a variety of examples of their efforts to directly impact science learning at the P–12 level and their intentions to do more. Teacher educator participants described their involvement with P–12 science education and their future intentions. These included volunteering for the summer science camp program, volunteering for the night at the museum event on campus, volunteering to do science programs for local elementary schools, giving presentations at local elementary schools, volunteering in P–12 schools, and being a resource for elementary educators. Amid reflecting on his service, Dr. Rogers said, "I feel like I am making contributions to young children who do those things, but I don't feel like I actually got any of that when I was . . . growing up." Dr. Knight described giving presentations at elementary schools: "I have gone in a couple of times and . . . I did a rocks and minerals day. I do this presentation that I've done at a bunch of different schools with Nemo, Dory, and Friends." Mr. Lewis who also has experience presenting in elementary schools, reflected on having larger audiences than anticipated, high elementary student excitement, and positive interactions with the elementary students. He said,

> I need to continue to do (presentations at local elementary schools). The local school corporation does not spend enough time teaching science. I think it's 30 minutes a week, and then when children, particularly the girls, get to middle school, they lose interest because, "I'm falling behind." So that's where one of our gaps is.

With regard to using the higher education institution as a resource, Dr. Zigler noted, "I'd hope that elementary educators, as they get educated to be teachers, maybe make some connections with people in the university system that can help them, and I don't know if that's happening at all." Of course to make this happen, it was noted that it was necessary for science departments to offer continuing assistance and communication about future opportunities for help to teacher candidates. It was also noted that students are informed of current partnerships between P–12 schools and the institution. Dr. Knight stated,

> They are made aware that on Mondays we have kids from other schools that come in and do activities, and they also know that we go out to schools, and so I hope that they recognize that when they become teachers, they can bring their students here or we can go to them.

Even though they may be made aware of such logistics, Dr. Knight was unsure if students were making the connections to the institution being a future resource. She mentioned that there was available equipment and that they "purposely don't schedule classes on Mondays so that other schools can come in on Mondays." In general terms, Dr. Zigler noted,

> Knowing that that support network is there and participating in it is pretty important for understanding how important science can be for society and also realizing that network of support needs to extend downward. It can't just be Ph.D.s looking out for each other, and that's something we don't do very well in the university system, I think.

Knowledge of the problem and progress. All teacher educator participants confidently acknowledged the gender gap as a problem that persists in science but acknowledged the progress that has been made. All teacher educator participants not only acknowledged the gender gap in science as real, they also detailed their knowledge of the gender gap in science with facts that they have learned via reading empirical evidence and/or experience. They also shared information regarding how progress has been made, whether they have seen or have not seen the problem in their current positions, and whether they still see it as a problem. Teacher educator participants understood the gender gap in science because they had been exposed to research findings in the literature. As Dr. Zigler put it, “Clearly there is a gender gap in science; we know that empirically, right?” Dr. Zigler also noted that nonwhite names and female names are more harshly peer reviewed. He related this to his personal experience with peer review rejection and that it made this phenomenon more obvious. Dr. Rogers described that literature on the gender gap in science presented data that is shocking. He reflected on some recent literature he had read by saying, “In general and in the geosciences, women are regularly underrepresented and particularly women of color.” He also pointed out the connection between geology and the oil industry and research related to oil industry that exemplified a strong anti-female bias.

Teacher educator participants shared many facts regarding the gender gap in science that they had learned through their personal experiences in science that acknowledge the gender gap in science. These experiential facts presented by participants included that women historically have had a hard time in science, that it was a “boys club,” and that the gender gap in science is a systemic issue in the sciences. The gender gap in science was derived from a culture of gender discrimination in science. Dr. Zigler stated that there was “a culture in science that makes it hard for women particularly, to be as successful as men regardless of their personal perspectives or the way they kind of behave themselves.” Also according to Dr. Zigler, the culture was rooted in the primal behavior of alpha male scientists and a high level of ruthlessness in the science process. And since the gender gap in science was a cultural problem, it may thus be more difficult to pinpoint. The culture is further supported by traditional gender role reinforcement because male gender reinforcement prepares males for the “boys club” environment. Even though not all male scientists may fit this stereotype, those who are in the presence of alpha males in science settings and are uncomfortable with the behaviors of their colleagues are likely not to speak up about it. Dr. Zigler divulged an admission of guilt regarding his own passive experiences. A lack of preparation and experience in the primal environment makes it more challenging for women. Dr. Zigler stated, “I have watched female colleagues, not struggle with that but be unwilling to be as ruthless as some male colleagues.” Dr. Zigler has also directly observed women being talked down to at public events and has observed women get shut down in meetings of scientists. In general, gender socialization is a disadvantage, and peer influence is a powerful force to work against as children grow up. As a dad, Dr. Zigler reflected on his daughter being influenced by princesses and unicorns and his son being influenced by rockets. He went on to describe his personal stance on gender socialization and that the odds were still against his children due to the heavy presence of gender stereotypes in society: “We don't do gender toys. We don’t talk about boys do this. We talk about human beings, right? But it still happens.” Other participant experiences that supported the gender gap in science being a cultural issue included having mostly male professors, having mostly male students in their college classes, or being treated differently than male counterparts. As Dr. Knight described, “I was in classes as an undergraduate where the male students were treated differently than the female students.” Teacher educator participants who had experience teaching at the secondary level also brought those experiences into their perspectives. Mr. Lewis remembered that his high school female students had a fear of science. He said,

> When I was teaching high school, a lot of the female students thought that chemistry and physics would be too hard to take, so we did a lot of recruiting and trying to tell young women that, “No, you're really going to need this; even as an elementary teacher, you have to take science.”

Dr. Rosenberg reflected,

> Actually, when I taught in [hometown], the middle schools and high schools, there was actually a gender gap. So the girls didn't like science. Some actually maybe their average test scores girls were better but their attitude and motivations, the boys were much better than girls.

Dr. Rosenberg also noted that differences among students were more apparent at the secondary level, and the gender gap in science becomes more visible in middle school and high school, where boys become dominant.

Teacher educator participants noted that the gender gap in science was not just defined by numbers of men versus women but by a variety of additional factors, including motivation, interest, achievement, attitude, and treatment. According to Dr. Rosenberg, the “gender gap in science means especially the attitude or motivation in studying science.” Dr. Rosenberg also noted, “To me the gender gap is maybe achievement and then especially more, not just achievement, more interest or attitude toward science.” And since there may be an even male/female student split in certain science majors at the undergraduate level, Dr. Knight noted,

> Students don’t recognize that there is a gender gap because I think that many of our undergraduate courses, they’re split pretty evenly between male/female, and then if they go on to graduate school, they start to see that there's either more women or more men, and then they start to think about why I don't have more female professors.

Dr. Knight also exemplified that recognition of the gender gap in science may happen even later when she said, “I knew it existed. I didn't necessarily realize how it affected me until I became a professor.”

Teacher educator participants who taught majority elementary education teacher candidates noted the opposite gender gap in their student demographic as well as the lack of gender gap in science among students at the elementary level. Mr. Lewis commented, “Actually, it probably goes the other way, that with the men in class I say, ‘Gentlemen, you're going to be a role model for these students.’” Since most of the elementary education majors were female students, the gender gap in science was not as noticeable for teacher educators of that demographic, and it may have in turn affected their inclination to reflect on the topic. In other words, the topic of the gender gap in science may have seemed less relevant. Or as Dr. Rosenberg put it, “All my students, most of my students are female. I have 25, 24, or 25 students every semester and usually one or two boys there.” Dr. Rosenberg also noted several times that there was no gender gap in science at the elementary level, and she based this upon her observations in elementary classrooms. She said, “Actually when I observe the elementary classrooms here, I don’t really see a big difference between boys and girls.” Dr. Rosenberg continued, “But elementary level, yeah, I don’t see it. I don’t see a really big difference.” Dr. Rosenberg concluded, “Yeah, so in the early age, there’s not a big difference in, between men, boys and girls, especially these days.” An exception was granted in her opinion due to the breakdown of boys versus girls at the institution’s summer camp. Dr. Rosenberg mentioned, “This summer camp, we don't really have a big difference in the number girls and boys but at the higher level . . . the fourth through sixth (grades), we usually have more boys than girls.”

Teacher educator participants recognized that progress has been made toward closing the gender gap in science. One teacher educator participant has had extremely asymmetric classes in the past, with one having only one woman, but noted that his current student rosters were balanced at both the undergraduate and graduate levels. In fact, only three out of 10 of his current graduate research advisees were male with the graduate student population becoming increasingly female. Dr. Rogers noted on the gender gap in geoscience when he stated,

> I think in general, women in geoscience have been doing better, certainly better than when I came through. When I was an undergraduate probably 10–15% of the students that were in classes with me were female, so most of them were male.

Mr. Lewis reflected on progress seen during his years as a secondary teacher and attributed this progress to the efforts of the high school teachers. Mr. Lewis said,

> There was a, I believe, a gender gap in there in that the young ladies had a fear of science and were not taking as much science, but we, I think, overcame a lot of that because it ended up that I was having a lot more females in my chemistry classes than males.

Mr. Lewis went on to say, "So I think with that type of encouragement, we can overcome the gap. And I think particularly in high school, that they are overcoming that now. They really are. We've got some great teachers."

With regard to the gender gap in science and their current positions, most teacher educator participants reflected on positive experiences. Low discrimination within the department, gender equity, and even a numerical balance between male and female colleagues were noted as reasons why the gender gap in science was not obvious in their current department(s). Nonetheless, it was noted that successful women colleagues were exceptions to the rule, implicating that they had pushed past the science "boys club" barrier to be in their current position. Dr. Zigler said, "So, you know, my own department at this institution, I would argue that there is not a lot of that. I mean, as a male observer." Dr. Zigler added, "The good scientists that I know don't think of, you know, a male idea and a female idea." Although most seemed to agree with this lack of in-house discrimination, one teacher educator participant had encountered gender discrimination in her current position, including treatment from students, colleagues, and administrators. Her experiences included becoming a mother, being addressed as Mrs. rather than Dr. by her students, and having her expertise questioned by administration.

Although teacher educator participants understood that progress had been made in narrowing the gender gap in science, there was still more work to be done in diversifying the science fields. Participants noted that asymmetry is still seen at the doctoral level, and the culture persists despite common knowledge of only physiological differences; the gender gap in science is a barrier to advancement; it's not men versus women with regard to ideas, and good science comes from gender balance in the contributors. Dr. Rosenberg said, "Generally, I think maybe we need more female scientists and engineers." Dr. Zigler had much to say on this subtopic: "I think it exists for sure; it's a problem, and it's a barrier to continued equalization in the sciences." He also said,

> A diversity of perspectives is the only way to move past many problems, and when we ignore or, you know, discount the perspectives of women in a science department or in a scientific discipline, we're losing half of the diversity of perspective, half the solution to issues.

And he stated, "Look, science is not easy. It doesn't matter what your gender is, but it is definitely harder for women, and it is going to take change in modeling behavior happening from the very beginning of education."

Educator preparation program capacity and personal responsibility. Teacher educator participants, although confident that the gender gap in science persists, were unsure whether the gender gap in science could be addressed by the EPP or whether they were personally responsible to address the topic with their classes. Nonetheless, they offered some suggestions. Reservations about the ability of the EPP being able to address the topic of the gender gap in science came from a variety of reasons, including the idea that it was too late to fix the problem at the collegiate level, low student ability level, high level of fear, crammed curriculum, content should take precedent, EPP capacity, few elementary education majors in science electives, and slow pace to progress. According to Dr. Rogers, it may be too late to address the gender gap in science problem because research/literature indicated that students are drawn into the field at the high school level. He felt, therefore, that it would be better addressed at the high school level. Dr. Rogers stated,

> By the time they are in college it's too late, you know? They've already become afraid of math or they're afraid of science. . . . I think that students in general are set in their ways by the time they get to college. I think a lot of it has to happen a lot sooner.

Dr. Rogers also said,

> I think it would be valuable to try to encourage women to be engaged in science, and I just feel like a lot of it has to happen at a level well before they get to college, and I can't do anything about that other than outreach, which I try to do as much as I can.

Interestingly enough, Dr. Rogers did not decide to major in science until after taking many science courses as electives as an undergraduate student and noted that, “When you look at the sort of research that's explored this, the things that drive women to our discipline or people to our discipline is usually having a positive undergraduate experience.” And he mentioned, “The part that I can influence is making sure that they have a positive undergraduate experience and potentially talk them out of the idea that science is impossible to overcome.” Dr. Rogers also noted that incoming undergraduate students may have a low ability in science, thus increasing their fear of math and science. He has made personal attempts to encourage current undergraduates to the major and has fallen short, especially with women, due to fear of calculus and physics.

Dr. Knight felt that it was a big hurdle to jump at the EPP level because of the systemic nature of the problem. It would also be impossible to add the gender gap in science topic to the existing Course A curriculum because of time limitations. Dr. Knight said,

> I don't know, I mean, you know, kids still have a perception that a scientist is an old white guy that wears a lab coat. Uh, and from my experience with my kids, they're not exposed to something different than that in school. So, for example, they have a science day every month and the person who leads science day is the one male faculty member in the entire school, and he happens to be an older white guy, and so they're not exposed to something that's different.

Dr. Knight also stated, "I don't (think the gender gap in science can be addressed), not in a class like Course A; I don't think so."

Dr. Zigler felt that intervention was needed and that the EPP may be able to address the issue but that there was no quick solution to the problem. Changes within EPPs would't cause rapid change but a general movement toward inclusivity would provide a consistent, slow momentum. As he put it, "So yes, I do think that elementary educators and educators all the way up can really affect change, but unfortunately, it's got to be a constant work."

There were few elementary education majors typically enrolled in Course A (a science elective) and therefore, it was not necessary to take the time to address the gender gap in science. As Dr. Rogers explained, "I do think it's important that they're (elementary education majors) aware of it, but it's not essentially the purpose of the class, and it's not most of the students in the class." He also noted,

> It’s challenging enough to get a bunch of people who don’t want to learn about science to learn about science. Course A is a foundations course with a lab so what we end up with is the people who are afraid of chemistry, biology, and physics come to this class so most of our class is composed of people who don't feel like science has an important role in what they want to do with their career and in general; the class is really taught to people who aren't interested in the field.

Teacher educator participants seemed open to the idea of teaching about the gender gap in science if it were to be offered via a separate course from what they were currently tasked with teaching or if they just had more time, in general. According to Dr. Rosenberg, “If I had more time, yeah, we could discuss more, so what can I say? Probably there is a responsibility, but it’s actually not covered a lot in my class.” Dr. Rogers said,

> As a program, if we had the capacity to add courses for women in science or courses that were for encouraging women in science, I think that would be beneficial, but I think probably the problem is that we have so few faculty that are teaching and the number of faculty is always being shrunk, not enlarged.

Dr. Knight commented that a history of science course was needed: “I would love to. I would love to be able to teach a course on the history of science or something that addressed that.”

Teacher educator participants also offered some suggestions to addressing the gender gap in science: constant work is required, influential people are needed in a child’s life to push past stereotypes, science instructors are needed who are open/frank about black marks in science, effort put forth against white male privilege is needed, effort put toward fixing the gender gap among elementary educators is needed, more male elementary education teachers are needed, and the topic of the gender gap in science addressed in relationship to the topic of the course is needed. Dr. Zigler expressed, “If it's not mentioned as it applies to the content material, then it’s falling short.”

Elementary Education Teacher Candidates’ Exposure to the Topic of the Gender Gap in Science from their Educator Preparation Program

According to Elementary Education Teacher Candidates

Address by coursework and strategies to engage student interest. Within the limits of this study, the topic of the gender gap in science has not been found to have been addressed in the coursework of the elementary education teacher candidates. Despite this finding, the teacher candidates provided an array of strategies to engage female student interest in science, with the origin of some of the strategies attributed to the EPP curriculum. No elementary education teacher candidate participants could recollect the topic of the gender gap in science having been addressed in any of their courses. The elementary education teacher candidate participants shared strategies to engage female student interest in science. These included general tips, democratic ideals, tips specific to girls, knowledge of students, teacher roles, and encouragement. They also shared general strategies, including making science interesting/fun, making science hands-on, making science connected to real life, allowing students to get dirty, providing research opportunities for students, and promoting self-guided exploration. As Abigail stated, let students “figure it out for themselves.” Strategies shared by teacher candidates that reflected democratic ideals were that science is for all ages, for male and female students, it is important to get all students involved, and boys should not be excluded. Other strategies focused specifically on girls and included math and science camps for girls, girls group work to discuss and do science, promotion of science clubs to girls, and splitting boys and girls to show them different things. Many strategies presented by elementary education teacher candidate participants focused on the importance of getting to know students, including their background knowledge, learning modalities, levels, goals, individual interests, and their lives (in order to connect science more specifically to students). Some shared strategies were specific to the roles of the teacher, including being a science role model for students, prioritizing science, and carrying out internal mental coaching. An example of being a female science role model was expressed by Natalie: “I guess just showing them that if I can teach science that they can be good at science, too.” With regard to making science a priority, Annie said, “I think making science more a priority so that kids do become interested.” Annie also talked about mental coaching. She expressed, “I’m always going to be like, ‘Science is important’ because when I don’t want to do science, I’m going to be like, ‘Science is important’. These kids need science.” The origin of the words she used within her mental coaching strategy came directly from this participant’s science methods instructor of the EPP.

And finally, some elementary education teacher candidate participants mentioned strategies that focused on providing encouragement to students to dream big and as Diana stated, “Show them that they actually are able to do these things, and show them what it might lead to in the future, then maybe it would have a positive impact, too.” The origin of these strategies, according to the teacher candidate participants who pinpointed them as such, included an EPP college science instructor, pre-student teaching internship classroom experience, personal experience, family, and original thought.

According to Teacher Educator Participants

Course A, Course B, Course C, and teaching strategies. An understanding of the courses taught by the teacher educator participants to elementary education teacher candidates as well as their teaching strategies within the courses was gathered to glean facts on elementary education teacher candidates' science content and science methods exposure in the EPP curriculum. Course A and the Course A lab section provided an introduction to environmental sciences. Course A was a content course with a crammed curriculum. Of the students who have taken Course A, usually a low percent of them have been elementary education majors. Although one teacher educator participant stated that she was unaware of what her students' majors were, another teacher educator participant described that there have been as few as two to three elementary education majors in one of his sections of course A and only up to 18–19 in a larger section. According to one teacher educator participant, Course A may have been selected by students as what the students perceived to be the easiest science course in the foundational studies options. There were a large number of Course A sections offered with a large number of instructors. Teacher educator participants shared that it was difficult to hold open discussions in courses such as Course A when the classes have been as large as 206 students. Nonetheless, discussion, lecture, class polls, and metacognitive strategies have been used. In the Course A lab section, the curriculum was scaled up elementary level curriculum. As Dr. Knight noted,

> Our goal in the lab is that anyone can do science, and so a lot of people come in to the class and they feel like they can't do science for whatever reason, and so we try to make it accessible to them.

Within the Course A lab section, students participated in guided lab work where they read background information, answered inquiry questions, listened to a brief lecture, setup the lab, and reflected throughout the lab. They were also afforded opportunities to "play" with equipment during non-guided lab work. Dr. Knight described,

> We have a lot of opportunity where they just get to kind of play with things, so they get to play with string tables; they get to play with wave tanks; they just get to experience whatever they want to with those, those labs.

Dr. Knight also stated,

> My goal is that when they come into the classroom, that they always have something that they couldn't have done on their own so they have to build something; they have to do some kind of experiment that they couldn't have just done at home on their own.

Course B and the Course B lab section were content-based and designed specifically for elementary education students as a reaction to their weakness in science. One participant noted that he was hired to teach in reaction to elementary education majors' weakness in science from lack of classes. It was also a course that was supposed to help elementary education majors prepare for their science licensure tests. The course covered chemistry and physics but not pedagogy or life science. The original curriculum was too advanced for the students and had to be pared down to meet the ability levels of the elementary education majors. Dr. Rosenberg described, "The purpose of that course (Course B) is to help elementary education students to be prepared for the license test."

Course C was a science methods course, although it did cover some science content. Students in the course were required to design and teach science lesson plans to elementary students. Students enrolled in the course may have or may not have been simultaneously enrolled in a pre-student teaching internship program. Students enrolled in spring and fall semester sections taught science lessons in local elementary classrooms; however, the students enrolled in the summer semester section taught science to the institution's summer science campers. Regardless of the semester, elementary education majors fulfilled part of the curriculum in a more traditional setting with their Course C instructor and fulfilled part of the curriculum in a clinical experience setting. It was in this setting that they got to experience teaching science lessons. Therefore, local P–12 educators, the Course C instructors, and the elementary education teacher candidates were connected through this course. Within Course B and Course C, instructor strategies shared by teacher educator participants included reading, hands-on activities using common/everyday materials, inquiry, real-life connections, question and answer, demonstrations/science magic tricks, exploration, group discussion, and the 5-E inquiry model. It was also noted that very little lecture was utilized. Dr. Rosenberg explained, "I just let them do something by themselves and then we kind of enjoy it together, so mostly my classroom activities are more hands-on and group discussion."

Direct address and indirect address. One out of five of the teacher educator participants directly addressed the gender gap in science topic with his students (of Courses A, B, or C), but all of the teacher educator participants felt that to some extent, they indirectly addressed the gender gap in science topic with these classes. Dr. Zigler was the only teacher educator participant who claimed that he directly addressed the topic of the gender gap in science with his Course A and that he took advantage of opportunities to discuss gender and race inequality with students. Dr. Zigler stated,

> Yeah, well, I think as a scientist who teaches people about science, doesn't matter if they're elementary education students or not, they need to know that the gender gap is real, that race gaps in science education are real, and so the very first week of my [Course A], I show graphs and statistics that show that women and people of color fare much more poorly in the peer review process than white dudes with names like mine, right?

> And, you know, there's a number of studies that show the peer review process is much more brutal for those whose names seem ethnic.

The remaining teacher educator participants made the following statements referencing that they have not explicitly taught about the gender gap in science to elementary education majors. Dr. Rogers put it simply when he said, "I think it comes up," and "I think it is all indirect." Mr. Lewis just described that he addresses the topic "to a certain extent." Dr. Rosenberg stated, "I don't really expressly teach gender, cover the gender issues," and "Ummm, I don't think so." Dr. Knight did not address it in course A but addressed the topic with some of her other classes. She said, "I do teach classes that are for majors where we talk about things like that."

Some teacher educator participants did share ways that they have indirectly addressed the gender gap in science topic with their students (enrolled in Courses A, B, and C). Discussions and activities throughout the semester covered topics such as science and society, education for women across the globe, fertility rate and population stability, responsibilities of elementary education teachers, general encouragement, instructor experiences, inclusivity, questioning bias, image of a scientist activity, and modeling equity. With regard to science and society, Dr. Zigler stated, "You talk about how everybody needs a shot to understand science, and if you don't understand science, doesn't matter who you are, you are going to be less prepared to live in the world." It could also be useful to connect job opportunities to the need for science. As Mr. Lewis reflected,

> I had one young lady that, really good in chemistry, but she just couldn't make up her mind what she wanted to do, and I say, "Let's let you shadow a pharmacist. There's a lot of chemistry there." And she thought that would be a great idea. She now has her doctorate in pharmacy.

The idea that women's jobs extend beyond household reproduction was discussed in class by Dr. Zigler and Dr. Knight. Dr. Knight stated, "We do talk a little bit about how the education of women is a really important factor that contributes to reduced poverty, and so we talk generally about why it's important to educate women, but we probably don't spend very much time talking specifically about the gender gap." On the same topic, Dr. Zigler noted, "The fact of the matter is that women finally have access to a university education much more easily than they did even when I was going through the system." Mr. Lewis communicated to his elementary education majors about the importance of knowing elementary students' backgrounds as well as the importance of the profession. He stated,

> "You're going to be extremely important. This is one of the most important jobs. I'm telling you, it is. You're going to be playing a very, very significant role in the lives of these children, whether it's second grade, kindergarten, fifth grade." And I want them to understand that so I want them to be the best prepared people they can be and they take hold of that.

He continued, "I want them to be aware of their responsibility, not only to teach them the subject matter, the content, but you're developing their personalities, and my students take hold of that. They really, really do." Mr. Lewis said, "I talk to them about experiences that I've had in the classroom." He was the only teacher educator participant who explicitly stated that this was a way that he indirectly addressed the gender gap in science with his students.

Dr. Rosenberg focused on questioning strategies with her students in Course C where they learned about unconscious bias when calling on students. Participation was likely to vary among their future elementary students, so as future elementary teachers, they needed to aim for inclusivity. Dr. Rosenberg explained, "Teachers need to kind of consider to include more students" and added, "When we talk about that, sometimes, we talk little bit about differences between boys and girls" (in reference to discussion with elementary teacher majors about questioning strategies). Dr. Rosenberg also did an activity with both her Course C students as well as her secondary education students in a different class. They were asked to draw a picture of a scientist, which probed for their image of a scientist. With regard to the results of this activity, she said, "My elementary education students, like 80% or 90% of drawings, show the man. But my secondary education students, there were more female scientists." She found that more of her elementary education majors held a stereotypical perspective of what a scientist might look like than did her secondary majors, who held a more diverse perspective on what a scientist might look like. The stereotypical look was that of a weird, male scientist. She attributed this difference to her secondary science education majors having had greater exposure to real scientists at the undergraduate level, which positively impacted their image of scientists. Conversely, elementary education majors' drawings of scientists reflected typical elementary and middle school student perspectives. She pointed out that elementary education majors may have been influenced by media rather than real scientists and that they had taken little science in the program.

Strategies to engage student interest. Although some of the teacher educator participants used strategies that elementary education teacher candidates could use to engage female elementary students in science, most used strategies that their elementary education teacher candidates could use to engage *all* elementary students in science. Strategies modeled or taught by teacher educator participants that their elementary education teacher candidates could use to engage their future female elementary students in science included apologizing to female students. An example came from Mr. Lewis who said, "I have to tell my female students that I'm sorry there were not female astronauts to begin with." Another strategy was choosing to use a female scientist role model. Dr. Zigler stated, "I didn't say, 'Here's a female scientist', right, but I did say, 'Look, here's a role model.' I know that's not an innovative practice because it's been done for a while, but I think it's pretty effective." Dr. Zigler expanded,

> I'm not saying, "Ok, here's (female scientist) who is amazing and female," I'm saying, "Here is an example of somebody who stood up even as large agriculture companies and actually some of her own colleagues were telling her to shut up and she pushed it forward anyway."

Other strategies used included talking about past and current women scientists, about how historically, female contributions have been ignored in science, and the progress that has been made. Additionally, exploring female student science talents, sharing personal and research experiences, and sharing examples of female student science success have been used by teacher educator participants that may be copied by their elementary education teacher candidates and, in turn, engage their future female elementary students. Dr. Zigler shared with his students anecdotal evidence from his research experiences, such as elevated female accuracy when he talked to husbands and wives separately.

Strategies modeled or taught by teacher educator participants that their elementary education teacher candidates could use to engage *all* of their future elementary students in science included a general aim for inclusivity. Dr. Knight explained, "I would say that we don't have anything that's directly applicable to female students. I don't think it is ever directly explicitly female versus male." Another indirect strategy was to teach the application. As Mr. Lewis explained, "We're teaching science, but we're also teaching at the same time that it's not just the science part of it; it's what you do with that science part of it." Also, assigning science research projects was an indirect strategy used that could engage the interest of all students. According to Mr. Lewis, “So, I had a student do a research project. Young lady—because she showed interest in science.” Other indirect strategies shared were to encourage male and female students, grab hold of extracurricular opportunities such as sponsoring science Olympiad, provide hands-on activities, conduct lectures, utilize the opportunity to make an impact on students’ career choices and science, make observations, and prepare *all* students for field work. Dr. Zigler shared that he tells his students,

> Look, we all have to get dirty collecting data; we all have to be uncomfortable collecting data, and if we only let certain people have this experience, we’re only going to have certain people being lit up by it, being willing to go out and do it again.

Dr. Zigler also stated, “You have to encourage people to explore these issues, doesn’t matter if getting dirty is for boys to do and you know, girls are supposed to play with dolls or whatever; that’s not going to help anybody learn.” More indirect strategies that surfaced included using examples of science and the scientific method being used in everyday life and teaching for the big picture. Dr. Rogers noted that people were simply unaware that they are using science techniques daily but that “it’s the way we view the world or how we address problems, or problem solving.” He also noted, in regard to daily use of the science process, “I mean there’s nothing inherently male or female about it, but I think basically it simplifies concepts that we sometimes find.” Experimenting, trying not to intimidate, and making real life connections were also discussed. Mr. Lewis pointed out, “I try to do real life all of the time.” Purposely stressing that science is important and making connections between the content and the students’ lives was pointed out by Mr. Lewis who used movies as an example: “I actually take time to talk about that” (movies with science/math connections). He also stated, “I asked my students, ‘Have you seen the movie Hidden Figures?'" Using data, informing students of current partnerships between P–12 schools and the institution, offering future assistance/using higher education institution as a resource, and discussing stereotypes versus reality were also mentioned with an example of a stereotype being lab coat nerds versus real people solving problems.

According to the Curriculum Artifacts

The syllabi and required textbooks for Course A, Course B, and Course C were analyzed for the presence or absence of 18 items: *gender gap in science (explicit address), women in science (explicit address or role model), inquiry-based teaching/learning, multiple intelligences approach to teaching/learning, science process skills, addressing alternative conceptions, hands-on learning, science materials for the classroom/science classroom environment, reading science-based materials, comfort with science, confidence with science, science guest teachers/speakers, science drawings, science interviews, science feedback, special science skills, encouraging female students in science, and the address of Indiana academic standards.* When one of these 18 items was addressed within an artifact, a level designator was added. Level one was used to signify that the concept was only introduced by an instructor, level two was used to signify that it was practiced by a student under instructor guidance, and level three was used to signify that it was practiced independently by a student in a project. Of the 18 items these artifacts were scrutinized for, 10 items were found within one or more artifacts. Of these 10 items, none were found in all of the artifacts analyzed. Table 2 depicts the numerical results of the curriculum analysis.

Table 2

Curriculum Analysis Data

Item	Course A Syllabi	Course A Required Textbook	Course B Syllabi	Course B Required Textbook	Course C Syllabi	Course C Required Textbook
Gender gap in science (explicit address)	N	N	N	N	N	N
Women in science (explicit address or role model)	N	Y - 1	N	Y - 1	N	N
Inquiry-based teaching/learning	N*	Y - 1	Y - 2	Y - 1	Y-3	Y-1
Multiple Intelligences approach to teaching/learning	N	N	N	N	N	N
science process skills	N*	Y - 1	Y - 1	Y - 1	Y -1	Y – 1
Addressing alternative conceptions	N	N	N	N	Y - 1	Y - 1
Hands-on learning	N*	N	Y - 2	Y - 1	Y - 2	Y - 1
Science materials for the classroom/science classroom environment	N	N	N	N	N	N
Reading science-based materials	N	N	N	N	N*	N
Comfort with science	N	N	Y - 1	N	Y - 1	N
Confidence with science	N	N	Y - 1	N	N	N
Science guest teachers/speakers	N	N	N	N	N	N

Item	Course A Syllabi	Course A Required Textbook	Course B Syllabi	Course B Required Textbook	Course C Syllabi	Course C Required Textbook
Science drawings	N	N	N	N	Y - 1	N
Science interviews	N	N	N	N	Y - 1	N
Science feedback	N	N	N	N	N	N
Special science skills	N	N	N	N	N	N
Encouraging female students in science	N	N	N	N	N	N
Address of Indiana Science standards	N	N	N	N	Y - 1	Y - 3

Note. Y = Present, N = Absent. If marked with a Y, a level designator was added. (1) The concept was only introduced by an instructor, (2) It was practiced by a student under instructor guidance, and (3) It was practiced independently by a student in a project. If marked with a N, an * may have been added to make a special note.

Items not found within any of the curriculum artifacts. The eight items that were not found within any of the curriculum artifacts were *gender gap in science (explicit address), multiple intelligences approach to teaching/learning, science materials for the classroom/science classroom environment, reading science-based materials, science guest teachers/speakers, science feedback, special science skills, and encouraging female students in science.*

Women in science (explicit address or role model). The item, *women in science (explicit address or role model),* was marked as present at a level of one in the Course A and Course B textbooks because both textbooks contained pictures and/or facts about women doing science and famous women scientists. Therefore, when students of Course A and Course B were utilizing their textbooks, they were at least exposed to this item.

Inquiry-based teaching/learning. The item, *inquiry-based teaching/learning,* was marked as present at a level of one in the Course A textbook due to the presence of a description for accompanying software and its ability to encourage the application of scientific inquiry skills. This item was marked as absent in the Course A syllabi; however, one of the course goals included the use of the scientific method, and it confirmed that students were required to purchase the course-related software. This may mean that they indeed utilized inquiry, but there was not enough information to mark this item as present. *Inquiry-based teaching/learning* was marked as present at a level of one in the Course B textbook because the concept of inquiry was discussed in the text. It was marked as present at a level of two in the Course B syllabi because the course description explicitly stated that it was inquiry-based. The course aims and objectives also explicitly referred to the comprehension and use of inquiry. *Inquiry-based teaching/learning* was marked present at a level of one in the Course C textbook because inquiry was found in the textbook in at least five sections. It was marked present at a level of three in the Course C syllabi because not only was inquiry embedded in the course description, the course learning outcomes, the course learning experiences, and the course topics, there was also a required assignment that specified that each student develop and teach three inquiry-based science lessons.

Science process skills. The item, *science process skills,* was marked present at a level of one in the Course A textbook due to the presence of a description for accompanying software that covered predicting and interpreting graphs and data. This item was marked as absent in the Course A syllabi; however, one goal included prediction. *Science process skills* was marked as present at a level of one in the Course B textbook and syllabus science process skills including measuring, graphing, and problem solving were listed and/or described. *Science process skills* was marked as present at a level of one in the Course C textbook and syllabi because process skills were explicitly listed and/or described.

Addressing alternative conceptions. The item, *addressing alternative conceptions*, was marked present at a level of one in the Course C textbook because the term, misconceptions, was explicitly discussed in three sections. This item was marked present at a level of one in the Course C syllabi because two of the course aims and one of the course topics spoke to elementary education teacher candidates understanding their own beliefs as well as their elementary students' beliefs.

Hands-on learning. The item, *hands-on learning*, was marked as absent from the Course A syllabi; however, a course goal included application of scientific theories. Nonetheless, it was not enough information to ascertain whether students of Course A were completing this in a hands-on fashion. *Hands-on learning* was marked as present at a level of one in the Course B textbook because the book contained a repeating section that told students to try various hands-on activities at home. And although it could not be determined whether the elementary education teacher candidates of the course actually did them, the hands-on nature of a variety of activities is at minimum presented to them. This item was marked as present at a level of two in the Course B syllabi because the use of experimentation and lab activities were explicitly and repeatedly described. *Hands-on learning* was marked as present at a level of one in the Course C textbook because there was a section about the 5-E learning cycle, which included an exploration stage. This item was marked as present at a level of two in the Course C syllabi because it stated, "For you to become a successful elementary teacher of science, you must experience what your students will experience. This means that you will spend a great deal of time doing science," and "We will spend a great deal of time doing the actual science lessons and method of learning."

Reading science-based materials. The item, *reading science-based materials,* was marked as absent in the Course C syllabi; however, within the learning experiences listed for the course, it was noted that reading about issues related to science teaching and learning would occur. Within the syllabi it was stated that "various readings will be distributed in class or on reserve for you to copy."

Comfort with science. The item, *comfort with science*, was marked as present in the Course B syllabi at a level of one because encouragement from the instructor was added. "SCIENCE is FUN!!!" was found within the syllabus as well as "Failure is not an option on my watch. I do not want anyone to fail my course. I will do all I can to make this class a successful experience for you. My motto is: Science is fun." Also found within the syllabus was, "We will have fun exploring the physical sciences. We will have some great discussions, do some great laboratory activities. It is my desire that you will love to teach science. You are all capable of doing the work." *Comfort with science* was marked as present in the Course C syllabus of one of the course instructors because encouragement from the instructor had been added: "Science can be very exciting for elementary students. It can be very exciting for you as well. If science can be made fun and exciting at the elementary level, students will learn."

Confidence with science. The item, *confidence with science,* was marked as present at a level of one in the Course B syllabi because a course aim and objective explicitly mentioned building confidence in science understanding and elementary science teaching during the course.

Science drawings. The item, *science drawings,* was marked as present at a level of one in the Course C syllabi because "use of drawings" was listed as an example of a way to understand students' ideas regarding science.

Science interviews. The item, *science interviews*, was marked as present at a level of one in the Course C syllabi because "interviewing" was listed as an example of a way to understand students' ideas regarding science.

Address of Indiana science standards. The item, *address of Indiana Science Standards*, was marked present at a level of three in the Course C textbook because it was a required component of the lesson plan template. This item was marked present at a level of one in the Course C syllabi because links of two websites were provided for students to visit both the Indiana state standards and the national science education standards.

Additional artifacts. One teacher educator participant provided five additional artifacts that he used within his courses to supplement the required textbooks. Although these artifacts were analyzed in the same fashion that the above artifacts were analyzed, and many items were marked as present at a level of one, the detail of the analysis has not been provided. The mention of this additional task only serves to note that if one instructor was using supplementary materials with his classes, others were likely doing the same. Whether it was in the form of textbooks, online videos, or other materials, instructors who choose to supplement the required curriculum artifacts with more of their own choosing may be influencing their students with regard to these items.

Summary

The results of this study were based upon elementary education teacher candidate personal interviews, teacher candidate personal interviews, and an analysis of curriculum artifacts that corresponded to Course A, Course B, and Course C. The major finding, with the exception of one teacher educator who verbally, directly addressed the gender gap in science topic with his Course A students, was that the EPP did not explicitly address the gender gap in science. Even though all of the teacher educator participants felt that to some extent they indirectly addressed the gender gap in science topic with these classes, the elementary education teacher candidates did not recollect learning about the topic from their coursework. Four of five teacher educators expressed that they did not directly address the topic with their classes and the syllabi, and required textbooks did not explicitly address the topic either. Though this finding was substantial, many additional important themes emerged from the data.

With regard to elementary education teacher candidate and teacher educator participants' backgrounds and demographic information, many interesting academic and personal experiences were uncovered. Especially, two of five teacher candidate participants experienced a time when they felt their gender identification set them apart for the worse and four of five teacher educator participants divulged a minimum of one experience in which they felt that their gender identification set them apart for the worse. Only the male teacher educator participants shared that they had experienced times when their gender identification set them apart for the better.

The general perceptions of both the elementary education teacher candidates and the teacher educator participants on the gender gap in science and responsibilities that accompany the problem were uncovered. Although the teacher educator participants had a much tighter grasp on the topic and were able to provide many details, the teacher candidate participants had varying levels of understanding and varying levels of confidence in their understandings of the gender gap in science. Similar to how the elementary education teacher candidates felt doubtful about their capacities to make an impact on the gender gap in science, the teacher educators were unsure whether the gender gap in science could be addressed by the EPP or whether they were personally responsible to address the topic with their classes. Nonetheless, they offered some suggestions. Interestingly, both elementary education teacher candidate participants and teacher educator participants offered strategies to engage female elementary students in science as well as *all* elementary students in science, but with the exception of one participant who mentioned the impact of a single course instructor, the teacher candidate participants did not attribute their knowledge of these strategies to the curriculum of the EPP.

Curriculum artifacts in the form of syllabi and required textbooks for Course A, Course B, and Course C were analyzed for the presence or absence of 18 items that related to the topic of the gender gap in science. Of the 18 items, eight were not found within any of the curriculum artifacts. Of the 18, *women in science (explicit address or role model), inquiry-based teaching/learning, science process skills, addressing alternative conceptions, hands-on learning, comfort with science, confidence with science, science drawings, science interviews,* and *the address of Indiana academic standards* were all present in at least one artifact. Additional artifacts were provided for analysis by one teacher educator participant, and it has been noted that teacher educators may supplement their required curriculum artifacts.

CHAPTER 5

SUMMARY AND DISCUSSION

Summary of the Study

The purpose of this qualitative exploratory case study was two-fold. First, it sought to investigate elementary education teacher candidates' perceptions toward the gender gap in science, their attitudes and responsibility toward closing it, and their potential strategies to encourage female student interest in science. Second, it sought to investigate teacher candidates' exposure to the topic of the gender gap in science from the EPP in which they were enrolled, including a variety of artifacts and their teacher educators' shared perceptions on the topic. Six research questions guided this study. Answers to the research questions of this case study, and more, emerged from the analysis of personal interview data from both the elementary education teacher candidate participants and the teacher educator participants. Additionally, analysis of curriculum artifacts of the EPP in the form of syllabi and textbooks afforded results to assist in providing a thorough examination of the case and to help answer the research questions of the study.

The broad results of the study, based upon the qualitative analysis of the interview data and curriculum artifacts, as they related to the research questions are as follows:

1. **What perceptions do elementary education teacher candidates hold relative to the gender gap in science?** Elementary education teacher candidate participants had varying

levels of understanding and varying levels of confidence in their understanding of the gender gap in science but thought that it was a problem that could be addressed, and although there are things that teachers can do to take on this responsibility, taking on the responsibility personally stirred up doubt. Nonetheless, certain motivational factors were present for them to do so. It is also important to note that two of five teacher candidate participants experienced a time when they felt their gender identification set them apart for the worse.

2. **What perceptions do elementary education teacher candidates hold relative to their responsibilities in closing the gender gap in science?** Elementary education teacher candidate participants felt that there was a responsibility of teachers to address the problem and that indeed, it was a problem that could be addressed. They offered many suggestions in light of acknowledging the responsibility of teachers.
3. **What perceptions do elementary education teacher candidates hold about taking on responsibilities toward closing the gender gap in science?** Elementary education teacher candidates acknowledged that the gender gap in science was a problem that could be addressed by teachers; however, they felt personally less responsible and/or that taking on the responsibility was intimidating.
4. **What ideas/strategies do elementary education teacher candidates possess that may afford them the opportunity to engage female student interest in science?** The teacher candidates provided an array of strategies to engage female student interest in science, with the origin of some of the strategies attributed to the EPP curriculum. Although some of the teacher educator participants used strategies that elementary education teacher candidates could use to engage female elementary students in science, most used strategies that their

elementary education teacher candidates could use to engage *all* elementary students in science.

5. **How does the curriculum of the EPP address the gender gap in science?** According to elementary education teacher candidate participants, the topic of the gender gap in science had not been addressed in their coursework. One out of five of the teacher educator participants shared that he directly addressed the gender gap in science topic with his students (of Courses A, B, or C); however, all of the teacher educator participants felt that to some extent, they indirectly addressed the gender gap in science topic with these classes. An understanding of the courses taught by the teacher educator participants to elementary education teacher candidates as well as their teaching strategies within the courses was gathered to glean facts on elementary education teacher candidates' science content and science methods exposure in the EPP curriculum. The analysis of the curriculum artifacts, syllabi, and required textbooks that corresponded to Courses A, B, and C confirmed the findings from the interview data as the gender gap in science was not explicitly addressed in a single artifact. However, just as teacher educators mentioned ways that they indirectly addressed the problem, the artifacts contained a number of items that were considered advantageous to promoting student interest and motivation in science, thus indirectly impacting the gender gap in science.
6. **What perceptions do teacher educators at the EPP hold relative to the gender gap in science that they share with their elementary education majors?** Based upon their teaching experiences, teacher educator participants shared strong thoughts about their elementary education teacher candidates and science as well as their habits of supporting and encouraging their elementary education teacher candidates. All teacher educator participants

confidently acknowledged the gender gap as a problem that persists in science but acknowledged the progress that has been made. Teacher educator participants, although confident that the gender gap in science persists, were unsure whether the gender gap in science could be addressed by the EPP or whether they were personally responsible to address the topic with their classes. Nonetheless, they offered some suggestions. Four of five teacher educator participants divulged a minimum of one experience in which they felt that their gender identification set them apart for the worse. Only the male teacher educator participants shared that they had experienced times when their gender identification set them apart for the better. Although all of the teacher educator participants had at least one, if not numerous, personal experiences related to the topic of the gender gap in science, only one teacher educator participant divulged that he shared his personal experiences with his elementary education majors.

As should be expected in a qualitative study, the data took on a life of their own. Thus, themes emerged from the lens of the participants that offered relevant insights to the topic but that did not explicitly address an original research question. These additional themes included background and demographic information about the participants. An understanding of the science backgrounds of the elementary education teacher candidate participants was constructed from information they shared related to their home experiences, academic experiences including the types of science and science activities they have encountered, and a number of influential people. Past and present contexts shed light on the science exposure and experiences of junior and senior elementary education majors. Overall, exposure to science and experience doing science among the elementary education teacher candidate participants was very limited in past and present experiences. Although participants were able to recollect both joyful engagements with science as well as science experiences that were dissatisfying, only one elementary education teacher candidate participant, who happened to be the only male, expressly stated that he liked science. Passive learning and ill-mannered teachers from their education were factors that related to elementary education teacher candidate participants' dislike of science. Experiments, real-life connections, and supportive teachers were factors that related to elementary education teacher candidate participants' fondness of science. The science fitness of the elementary education teacher candidate participants, their confidence in science, and their feelings of preparedness for elementary science teaching were mostly low, and their comfort with elementary science teaching was variable.

An understanding of the science backgrounds of the teacher educator participants was constructed from information they shared related to their home experiences, academic experiences at different levels of education that included the types of science and science activities they have encountered, motivational experiences, and a number of influential people. The degrees, rank, titles, and courses taught at the institution provided context for the influence they have had on elementary education teacher candidates. All of the teacher educator participants were passionate about science and/or teaching. Although they have had both good and bad experiences relevant to science and/or teaching, they collectively possessed a wide array of traits that exemplified extreme fitness to be working as scientists/science educators. These traits may be beneficial for elementary education teacher candidates to learn about, work on in themselves, and recognize and foster in their students. Teacher educator participants shared a variety of examples of their efforts to directly impact science learning at the P–12 level and their intentions to do more.

Discussion of the Results

During the formulation of the literature review of this study, research that specifically discussed whether the science gender gap is addressed in EPPs or how teacher candidates perceive it was not found. Therefore, the results of this exploratory case study partially fill a deficit in the literature by tying together theoretical constructs and research on the gender gap in science with research about teacher candidates' perception of the problem and how the curriculum of their respective EPP addressed the problem. As instructors of the biggest pipeline for potential future female scientists, it is critical to understand not only their perceptions toward the gender gap, but also their exposure to the topic from their EPP. This exploratory case study provided such insights.

The implications of the results of this study are numerous. Although the gender gap in science was acknowledged by almost all participants as being a problem that needs addressed, neither elementary education teacher candidates nor teacher educators had great confidence in their responsibilities or capacities, at least in their current positions, to address the issue. And because the gender gap in science was thought to be a systemic problem, a culture, as some teacher educators pointed out, shouldn't those within education, those with the greatest ability to impact the youth of society, be equipped with the knowledge of the problem and the tools to make a difference? The results of this study divulged a notable difference between the knowledge of the gender gap in science between the teacher educator participants and the elementary education teacher candidate participants. The elementary education teacher candidate participants had much less breadth and more surface knowledge of the topic compared to the teacher educator participants who had greater breadth and depth of knowledge regarding the topic.

The theoretical framework of this study was built upon social constructivism, multiple intelligences theory, and feminism. Bachtold (2013) proposed three suggestions to enhance science teaching based on personal and social constructivism. Of the three suggestions, two were found to some extent from the results of the current study: the idea that teacher and students should coordinate their actions and ideas in order to complete scientific inquiry and the idea of incorporating the study of real science problems throughout history. The analysis of curriculum artifacts did reveal a focus on scientific inquiry within Course A, Course B, and Course C. Moreover, inquiry, the scientific method, experimentation, and real-life connections were topics discussed by either elementary education teacher candidate participants or teacher educator participants as strategies to increase student interest in science.

Adcock (2014) supported the continued importance of using multiple intelligences theories to meet student needs. Adcock found that a multiple intelligence course taken by K-12 educators was valuable in several ways, but one noteworthy finding was that the course was helpful in their learning how to boost motivation and interest of their students. If multiple intelligences strategies are employed in the classroom, the teacher would have the opportunity to learn their individual student strengths and feed those strengths utilizing the most suitable science teaching strategies they have in their teacher toolbox, so to speak. Although one elementary education teacher candidate did note the importance of getting to know students and adapting lessons to student backgrounds, that just vaguely speaks to multiple intelligences theory. Additionally, multiple intelligences theory was not explicitly mentioned as being a part of the EPP curriculum during participant interviews, and it was not explicitly addressed in any curriculum artifacts. Although the absence of multiple intelligences theory in an explicit form was not surprising, the lack of conversation around learner differences relevant to science or the gender gap in science is bothersome, especially when the Indiana educator standards speak to learner differences so greatly.

A key implication from the results of this study is a general lack of awareness and responsibility regarding the gender gap in science. With regard to feminist theory as described in chapter two, feminist theory provides a link between the historical oppression of women to continued research on the gender gap in science. According to Jagger and Rothenberg (1993), feminist theory identifies and exposes the subordination of women. Of the five elementary education teacher candidate participants, the single male participant seemed the most knowledgeable on the topic of the gender gap in science. In a field like elementary education, where most of the teachers are female, it is all the more important that they have an awareness of the topics that have historically oppressed women and continue to affect them. Lack of awareness instigates a lack of responsibility, as exemplified by comments made by Annie. And with a lack of responsibility, science may continue to be taught as a backburner subject. Hesse-Biber and Brooks (2007) explained that there are women who think that feminists are pointlessly excessive, look stereotypically un-feminine, and are fighting a fight that has already been won. However, the point well made by Hesse-Biber and Brooks is that the level of gender discrimination women may face today is in great part due to the feminist activism that has taken place and is ongoing. With regard to the results of this study, the varying levels of understanding and varying levels of confidence in their understanding of the gender gap in science held by the elementary education teacher candidate participants, including some naivety to its presence, is not surprising but still undesirable.

The hybrid paradigmatic lens of this study was built from the social constructivist and feminist paradigms. To exemplify the multiple realities view of both of these paradigms, every participant in this study had varying life and curricular experiences shaping their attitudes toward the gender gap in science, even though they were all a part of the same EPP. The enormous number of codes and the variety of codes that resulted from the data analysis process speak to this characteristic. According to Hesse-Biber (2006), “Feminist research begins with questioning and critiquing androcentric bias within the disciplines, challenging traditional researchers to include gender as a category of analysis” (p. 5). This study was built upon a feminist paradigm, which means that it had a particular lens through which the results were gleaned. Those results, although not highly generalizable due to the nature of the case study, are still an effort to chip away at the androcentric bias that continues to permeate society.

The capacities and efforts of teacher educators to be social justice advocates and share their wealth of knowledge and experiences regarding the topic may enhance the responsibility felt by the future elementary teachers. The conclusions of an autoethnography by Kelly-Jackson (2015) about her journey as a social justice teacher educator enveloped gender as one of a large number of social justice issues that affected her educational journey. Gender was one of six social justice issues integrated into Kelly-Jackson’s curriculum. One finding from this study is that a teacher educator’s lived experiences can impact their teachings as social justice educators. (Kelly-Jackson, 2015). All of the teacher educator participants of the current study had at least one, if not numerous, personal experiences related to the topic of the gender gap in science. However, only one teacher educator participant divulged that he shared his personal experiences with his elementary education majors. Carinci (2002) found that most of the teacher educators whom she interviewed communicated that they did not draw as much attention to gender equity as they should. Data collected via graduate surveys and course syllabi in the Carinci study confirmed that gender equity was only addressed minimally and in superficial ways. The results of the current study are congruent with the findings of Carinci such that only one teacher educator directly addressed the topic of the gender gap in science with his students of Course A and that the topic was not explicitly found in any of the curriculum artifacts. By interviewing teacher educators and teacher candidates about the gender gap in science, the research simultaneously raised awareness of the issue with the interviewees.

Although three of the teacher educator participants recognized the opposite gender gap among elementary teachers and this recognition did seem to affect them, it did so in a way that seemed to work as a disadvantage in addressing the gender gap such as being less aware of the problem. There did not seem to be a connection made between having primarily female students in their classes and preparing them to take on the responsibility of being female science role models for all of their future elementary students, but especially for their future female elementary students. Dr. Rosenberg and Mr. Lewis pointed out the opposite gender gap they had among their elementary education majors, which aligns with statistics of the U.S. Bureau of Labor and Statistics (2015), that close to 97% of pre-school and kindergarten teachers are women, and close to 81% of elementary and middle school teachers are women. This opposite gender gap, prevalent in education, affords female educators the opportunity to exemplify great science knowledge and skills to their female students. Research conducted by Dee (2006) and Cotner et al. (2011) support the notion that instructor gender matters, where girls have better outcomes when taught by female teachers. However, neither elementary education teacher candidate participants nor teacher educator participants presented the opposite gender gap of elementary teachers as a possible solution to the problem. In fact, one teacher educator participant, Dr. Knight, even questioned whether more male elementary teachers were the solution when she said, “I mean I don’t know if the solution is to have more male elementary education teachers." And another, Dr. Rosenberg, expressed her tendency not to be attentive to the topic of the gender gap in science because of the opposite gender gap seen among her elementary education majors.

One teacher educator participant repeatedly noted that the gender gap is not seen at the elementary level but becomes more visible at the secondary level. This is corroborated by the literature, which shows the gender gap in science does not seem as apparent at the younger grade levels. However, it is important to note that much of the statistical data collected on the topic comes from the secondary and postsecondary education levels (Cunningham & Hoyer, 2015; National Center for Education Statistics, 1997).

Because the literature has mixed results on when the divergence occurs, it is important to start at the beginning, the elementary school grade levels. This study intentionally aimed at elementary education in part because it was safely in the time zone before the divergence occurs. The impact that could be had at the elementary level with regard to the gender gap in science is unknown, and the results of this study do not speak to this either. Rather, they solidify the knowledge that little science is being experienced at the elementary level. Both sets of participants noted, based on their personal experiences, their clinical experiences, and their observation experiences, that there was a notable lack of science being done at the elementary level, especially hands-on science. This supported the literature foundation of Avery and Meyer (2012), whose study was built upon the dearth of science teaching in elementary schools and the low self-confidence of elementary teachers. The lack of science experiences of the elementary education teacher candidates of this study along with their lack of science teaching experiences and low confidence also align. Might simply having more authentic, hands-on science experiences at the elementary level, led by a female science teacher role model, be influential on female elementary students' interest and motivation in science for the long run? This question, although interesting, was in no way addressed by the results of the study. What the results of the study were able to do was link the two topics of elementary education preparation and the gender gap in science. The concern is then two-fold: to make sure all educators, including elementary educators who are the first traditional academic influence on our youth, not only understand what the gender gap in science is and how they can help fix it but that they have to be capable and motivated to consistently facilitate reality-based, hands-on, inquiry-based science exploration with their diverse elementary students. The in-depth fifth and sixth grade science experiences of one teacher educator who recalled them being almost exactly what she ended up doing in college labs, less the advanced math, really drives this implication home. It is not too early to make an impact on elementary students with regard to science.

Many specific strategies to engage female student interest in science or elementary student interest in science were established in the literature review. A few of the strategies presented by Payne (1997), Tank and Coffino (2014), and Hardin and Longhurst (2016) in the literature review of this study also appeared in the results. These strategies included the use of hands-on activities, the use of female role models, which were both topics discussed by participants during interviews, and the use of drawing as an assessment tool, which was found in the syllabus of Course C and discussed by one of the teacher educator participants. Although these strategies are congruent with the literature review for this study, many other strategies from the literature review were not expressed in the results of the study, including the strategies of Lacueva (2014) and some of the strategies of Payne, Tank and Coffino, and Hardin and Longhurst. Lacueva's strategy, which was not directly expressed in the results of the current study, was that of integrating theory and practice into the curriculum via weekly news, book/web page/video, science/technology activity, instrument/kid examination, reflective essays on education practice, student school projects, and class reflections. Payne's strategies not expressed in the results of the current study included reading about science and providing science reading materials, utilizing female students with a high level of interest in science as a way to gather information and promote interest for their other students, and seeking out science experts to come into their classroom. Tank and Coffino's strategy not expressed in the results of the current study was learning and using science vocabulary but in a way that is connected to actually doing and communicating science. And Hardin and Longhurst's strategy not expressed in the results of the current study was the overt encouragement of girls to pursue STEM. Vice versa, ideas/strategies, different from the literature review, regarding the promotion of elementary student interest in science surfaced in the results. Making real life connections, holding and promoting science camps and clubs for girls, assigning girls group work in science, providing general encouragement, making science a priority, apologizing to female students, exploring female science talents, sharing research experiences, aiming for inclusivity, and conducting experiments were some of the ideas/strategies shared collectively by elementary education teacher candidate participants and teacher educator participants.

Inquiry-based science teaching is a popularly emphasized method for teaching science. Its emphasis in an EPP's curriculum would not be surprising. However, a qualitative case study conducted by Villa and Baptiste (2014), which was built upon a socio-culture learning theory, addressed a disconnect between the acknowledgement of the effectiveness of teaching science via inquiry from its actual employment. Although topics related to inquiry-based science were discussed within the elementary education teacher candidate interviews, it is important to note that not a single elementary education teacher candidate participant explicitly used the word *inquiry* when discussing strategies to engage student interest in science or with regard to their own science experiences.

Yilmaz-Tuzun (2008) conducted research to ascertain pre-service teachers' beliefs about science teaching and determined that approximately two-thirds of those surveyed took only one to three science content courses. It was also found that there is a positive relationship between the number of science courses taken and the student's confidence using different teaching methods. Additionally, students from this study had greater confidence teaching biology and earth science content over physics and chemistry content. The results of this study are at least partially in line with the findings of Yilmaz-Tuzun because the elementary education teacher candidates in the current study were only required to take one science course and one science methods course in their program. Also, one elementary education teacher candidate presented the idea that confidence is relative to the science subject. However, the science subjects that he felt more or less confident in were not expressed.

Though the lack of confidence, interest, and motivation in science held by the majority of the elementary educator participants of this study was not surprising, it was disheartening to learn, nonetheless. If those studying to become elementary teachers dislike science, as did four of the five who were interviewed in this study, they are carrying that attitude with them into their future classrooms. Although the teacher educator participants of this study expressed their diligent work to aid this problem, more can be done. The results of the study confirm that teacher educators are working to impact science at the P–12 level but there may be a disconnect between the EPP as a resource and the elementary education teacher candidates. The resources the EPP might be willing and able to provide future elementary teachers are important, but an established network between these stakeholders might begin when the elementary education teacher candidate participants are still in the EPP by taking the time to share their stories. The interview data shared by the participants were constructed not only from their experiences within the EPP that they were students/instructors within, but also through a wide array of personal and prior academic experiences. The unique science experiences, both in and out of traditional academic settings, that the teacher educator participants shared could be examined by the EPP and elementary education teacher candidates so as to provide support in the form of real-life examples to carry with them into their future classrooms.

The results of the syllabi and textbook analysis revealed that a variety of items that either relate to the gender gap in science or have an influence on student science interest and motivation were found, but there were a number of items that were also absent. It was learned in the process of examining the artifacts that a holistic picture of the curriculum was not presented by the books/syllabi in and of themselves. Therefore, the absence of items within these artifacts does not imply that the curriculum is actually deficient in all of them, only what was confirmed by the interview data, which was the absence of the topic of the gender gap in science in an explicit form. One item, however, that was not found within the artifacts and was not mentioned (although it was not specifically asked) by teacher educator participants was that of the presence of the multiple intelligences theory as a way to impact science at the elementary level. Interestingly though, participants pointed out the importance of getting to know the elementary students as a strategy to engage them in science.

Recommendations

Recommendations for Elementary Education Teacher Candidates

Listed below are recommendations for elementary education teacher candidates that were gleaned from the results of the study. These recommendations were developed as a reaction to the elementary education teacher candidate participants' shared personal/academic experiences. They were also developed from the insights of the teacher educator participants.

- As the participants of this study did, elementary education teacher candidates should reflect on their P–12 science experiences within school. They should develop their science autobiographies so as to shed light on what aspects of science they liked and did not like. They should work on locating their scientific selves and bring that with them into their future elementary classrooms every day. They should be aware of the gender biases they bring into their classrooms and work diligently to reject gender labels.
- Elementary education teacher candidates should break the cycle of science being pushed to the backburner, and being reading, lecture, or worksheet based.
- Elementary education teacher candidates should get to know their students, specifically their individual intelligences, and design science instruction around the characteristics of their learners.
- Elementary education teacher candidates should do hands-on science consistently with their future elementary students.
- Elementary education teacher candidates should build a network to help them secure science resources. Specifically, they should reach back out to their college institutions and utilize the science instructors, science education instructors, and the science equipment.
- Elementary education teacher candidates should talk about female scientists or bring female scientists in as guest presenters.

- Elementary education teacher candidates should be real-life science role models for their students. They can do this by showing interest, being confident, and showing excitement with regard to science.
    - Female elementary education teacher candidates should know that the gender gap in science persists, and although it may not be visible yet among their students, they have an opportunity to be positive female science role models for their students. This is an important responsibility.
    - Male elementary education teacher candidates should know that the gender gap in science persists and that they have an opportunity to be positive science role models for their students. This is an important responsibility.
- Elementary education teacher candidates who have a student who shows specific interest in science or a science subject should challenge her or him and assign them a special project.
- Elementary education teacher candidates should consider sponsoring a science club at the elementary school.
- Elementary education teacher candidates should make real-life connections within science lessons and connect the science to students' interests.

Recommendations for the Educator Preparation Program/Teacher Educators

Listed below are recommendations for the EPP and teacher educators that were gleaned from the results of the study. These recommendations were developed in response to the finding that the elementary education teacher candidate participants did not recollect the gender gap in science being addressed in any of their EPP courses as well as the point that four of the five teacher educator participants did not directly address the topic within their courses.

Additionally, these recommendations were developed in response to the absence of the topic of the gender gap in science being explicitly found in the curriculum artifacts that were examined.

- The EPP/teacher educators should add the gender gap in science topic explicitly to the science/science education courses within the existing curriculum.
    - Teacher educators should explicitly talk about it with their students.
    - If possible, teacher educators should incorporate the topic of the gender gap in science as it applies to the science content material.
    - Teacher educators should embed the topic of the gender gap in science into the syllabus for the course.
    - Teacher educators should design an assignment around the topic.
    - Teacher educators should discuss the importance of female science role models for female elementary students. Being that there is an opposite gender gap among elementary educators, female elementary education teacher candidates can *be* the female science role model. Male elementary education teacher candidates should also prepare to be science role models.
- The EPP/teacher educators should add a required course for education majors that provides teacher educators with ample time to cover the topic of the gender gap in science.
    - An example may be to add a course on social justice topics for education majors or to add a history of science course that addresses the gender gap in science.
    - Teacher educators should study and learn from other EPPs that have implemented such a course. For example, Erden (2008) tested the effect of a gender equity education course on the attitudes of pre-service early childhood and elementary

teachers. The results of implementing a gender equity education course were markedly improved attitudes toward gender issues. Erden noted that teacher education programs focus on content and pedagogy, but they fail to address gender equity issues.

- EPPs, specifically clinical placement coordinators, should be thorough in learning about the amount and type of science that is done each day by cooperating teachers before assigning elementary education teacher candidates to them for their pre-student teaching internship or for their student teaching placement.
- EPP teacher educators of science content or science education courses should consider sharing their own experiences relative to the gender gap in science with their education majors. Only one of five of the teacher educator participants shared that he did this; however, all of the teacher educator participants had at least one, if not many, life experiences that would serve as tremendous teaching tools. The addition of personalized, real-life experiences of the instructor to the formal curriculum may be a gateway to helping teacher candidates, and thus future teachers, understand that the gender gap in science is a real problem and that indeed, they have the potential to make a positive impact.
    - EPP teacher educators should share examples of personal experiences that demonstrate their positive influence on female students in science.
    - EPP teacher educators should share examples of being influenced by female science role models.
    - EPP teacher educators should share examples of being set apart for the better or the worse due to their gender identification and how it made them feel.

- EPPs should establish a formal partnership between elementary education majors and science instructors/science education instructors at the institution so that awareness is brought to the potential benefits of both stakeholder groups.

Recommendations for Future Research

Listed below are recommendations for future research that were gleaned from the results of the study as well as its limitations. These recommendations were drawn from topics and experiences shared by the elementary education teacher candidates and the teacher educators. Additionally, the lack of direct address of the gender gap in science in the curriculum of the EPP built the foundation for these recommendations.

- Researchers might consider conducting action research on the impact of explicitly adding the topic of the gender gap in science to the EPP curriculum which may afford the opportunity to determine if the perceptions of elementary education teacher candidates are changed with regard to the topic.
- Researchers might attempt to determine exactly how much hands-on science is being taught by elementary education teacher candidates during their student teaching placement and how prepared these elementary education teacher candidates feel to teach science at the elementary level after they complete student teaching.
- Researchers might attempt to identify and study a thriving science network between elementary teachers and postsecondary institutions as a pre-requisite to action research.
- Researchers might consider completing action research on the implementation of a formal science partnership between elementary education majors and their EPP that extends into the elementary education majors' first few years of teaching.

Summary

A summary of the study, discussion of the results, recommendations for elementary education teacher candidates, recommendations for the EPP and teacher educators, and recommendations for future research have all been detailed in this chapter. The overall results, as they pertain to the research questions of this study, included that elementary education teacher candidate participants had varying levels of understanding and varying levels of confidence in their understanding of the gender gap in science but think thought it was a problem that could be addressed by teachers. However, they felt personally less responsible and/or that taking on the responsibility was intimidating. The elementary education teacher candidates shared strategies to engage female student interest in science, with the origin of some of the strategies attributed to the EPP curriculum. Some of the teacher educator participants used strategies that elementary education teacher candidates could use to engage female elementary students in science but most used strategies that their elementary education teacher candidates could use to engage *all* elementary students in science. According to elementary education teacher candidate participants, the topic of the gender gap in science was not addressed in their coursework. This finding was solidified by the result that only one out of five of the teacher educator participants directly addressed the gender gap in science topic with his students. All of the teacher educator participants indirectly addressed the topic of the gender gap in science with their classes. The analysis of the curriculum artifacts, syllabi, and required textbooks that corresponded to courses taught by the teacher educator participants to elementary education majors confirmed the findings from the interview data. The gender gap in science was not explicitly addressed in a single artifact. Just as teacher educators indirectly addressed the problem, the artifacts contained a number of items that may be considered advantageous to promoting student interest and motivation in science, thus indirectly impacting the gender gap in science. Teacher educator participants shared strong thoughts about their elementary education teacher candidates and science as well as their habits of supporting and encouraging their elementary education teacher candidates. All teacher educator participants confidently acknowledged the gender gap as a problem that persists in science but acknowledged that progress has been made. Teacher educator participants, although confident that the gender gap in science persists, were unsure whether the EPP had the capacity to address the gender gap in science or whether they were personally responsible to address the topic with their classes.

The discussion weaves the theoretical framework and hybrid paradigmatic lens with the results, expressing that the results of the study chip away at the androcentric bias that still permeates the field of science. Furthermore, relationships between the results of the study and the literature review were described. Many of the results corroborated the literature; whereas, some results were an extension to it, and still others were unique ideas compared to the review of literature conducted for this study. Specifically, the connection of the topic of the gender gap in science with that of educator preparation fills a deficit in the literature. With regard to the theoretical framework, elements of personal and social constructivism corroborated the literature, but that of multiple intelligences theory was almost completely missing from the results of the current study. Also within the theoretical framework, corroboration was found with regard to feminism in the lack of acknowledgement/knowledge of the problem among female elementary education teacher candidate participants. Pertaining to the hybrid paradigm of this study, the enormous amount of detail and variety within the results speak to the multiple realities view of both the social constructivist and feminist paradigms. Although literature support for the abilities of social justice educators was found, the results of this study explicitly expressed that only one teacher educator participant shared personal experiences as a teaching strategy. Of the many teaching strategies presented in the literature, only some were expressed in the results of the current study. Vice versa, ideas/strategies different from the literature review regarding the promotion of elementary student interest in science surfaced in the results. The absence of the explicit address of the gender gap in science by four of the five teacher educator participants as well as its complete absence from the curriculum artifacts was congruent with the idea that gender equity is only addressed minimally and superficially within an EPP. Also congruent with the literature were results, which expressed the lack of gender gap in science seen at the elementary level, the dearth of science teaching in elementary schools, the low self-confidence of elementary teachers, and the lack of science taken by elementary education majors within their EPP. And pertaining to the opposite gender gap seen among elementary teachers, the results of this study did not express knowledge of nor support for the use of this opposite gender gap as a tool to positively impact the gender gap in science.

In response to the cumulative results of the elementary education teacher candidate participant interview data, the teacher educator participant interview data, and the curriculum analysis data, recommendations for three different stakeholder groups were developed. The topics and experiences discussed by participants, as well as the presence or absence of the topic of the gender gap in science being directly addressed by the curriculum artifacts, provided a foundation for these recommendations. The recommendations for elementary education teacher candidates included conducting personal reflections on science experiences, breaking the cycle of a lack of science teaching at the elementary level, knowing learner characteristics, doing hands-on science, building a science network, using female scientists in the curriculum, being a science role model, assigning projects to interested students, sponsoring a science club, and making real-life connections. The recommendations for the EPP/teacher educators included adding the gender gap in science topic to the curriculum, adding a new course to the curriculum, learning about the science teaching of cooperating teachers before placing students, sharing personal experiences with students relative to the gender gap in science, and establishing formal partnerships with elementary education majors. The recommendations for future researchers include conducting action research on the impact of adding the topic of the gender gap in science to the EPP curriculum, determining the amount of hands-on science being conducted by elementary education teacher candidates during student teaching, and identifying a successful science network as a model.

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APPENDIX A: TEACHER CANDIDATE INTERVIEW PROTOCOL

Teacher Candidate Interview Protocol

Time of interview:

Date:

Place:

Interviewer: Bridget Ireland

Teacher Candidate Interviewee:

Position of interviewee: (e.g. undergraduate elementary education major in final two years of their program)

Administration of Informed Consent

Questions and potential probes:

1. Tell me a little bit about yourself.
    a. What is your major?
    b. What year into the program are you?
2. What is the gender gap in science?
    a. Do you think that the gender gap in science is a problem that can be addressed? If so, how might it be addressed?
3. What responsibilities do you think a teacher might have in closing a gender gap?
4. How do you feel about taking on the responsibility of closing the gender gap in science?

5. What ideas/strategies do you have that may afford you the opportunity to engage female student interest in science?
    a. How did you learn these ideas/strategies?
6. Can you recall any courses you've taken that have addressed the gender gap in science?
    a. If so, how?
    b. What ideas/strategies did your instructor(s) or the curriculum present?
7. Do you like science?
    a. How confident are you with science subjects in general?
    b. How prepared do you feel to teach science at the elementary level?
    c. How comfortable are you with teaching science at the elementary level?
8. What memories do you have of joyfully engaging with science?
    a. Earliest memory?
    b. Most recent memory?
9. What past experiences with science were dissatisfying?
    a. Earliest memory?
    b. Most recent memory?
10. What academic experiences have impacted your attitude toward science?
11. What personal experiences have impacted your attitude toward science?
12. Who has positively or negatively impacted your attitude toward science?
    a. How so?
    b. Certain teachers?
    c. Family or friends?

13. In a personal or academic setting relevant to science, have you experienced a time when you felt that your gender identification set you apart for the better or worse?

APPENDIX B: TEACHER EDUCATOR INTERVIEW PROTOCOL

Teacher Educator Interview Protocol

Time of interview:

Date:

Place:

Interviewer: Bridget Ireland

Teacher Educator Interviewee:

Position of interviewee: (e.g. teacher educator of the elementary education program)

Administration of Informed Consent

Questions and potential probes:

1. Tell me a little bit about yourself.
    a. What courses do you teach to elementary education majors?
    b. What areas did you earn your undergraduate and graduate degrees in?
2. What are your perceptions of the gender gap in science?
    a. Is it something that can be addressed by the EPP?
3. Do you feel that as a teacher educator, you have a responsibility to teach your elementary education majors about the gender gap in science?
4. Do you directly address the gender gap in science with your classes?
    a. If so, how?
5. Do you indirectly address the gender gap in science with your classes?

    a. If so, how?

6. What ideas/strategies do you teach your students that may afford them the opportunity to engage female student interest in science?
    a. How do you teach them these ideas/strategies?
7. Do you like science?
8. What memories do you have of joyfully engaging with science?
    a. Earliest memory?
    b. Most recent memory?
9. What past experiences with science were dissatisfying?
    a. Earliest memory?
    b. Most recent memory?
10. What academic experiences have impacted your attitude toward science?
11. What personal experiences have impacted your attitude toward science?
12. Who has positively or negatively impacted your attitude toward science?
    a. How so?
    b. Certain teachers?
    c. Family or friends?
13. In a personal or academic setting relevant to science, have you experienced a time when you felt that being male/female set you apart for the better or worse?

APPENDIX C: CURRICULUM MAPPING TABLE

Curriculum Mapping Table

The curriculum-mapping table, adopted in consultation with my committee, has been modified to fit the topic and needs of this study and has been partially developed as follows:

	EPP Course title and designator	EPP Course title and designator	EPP Course title and designator	EPP Course title and designator	EPP Course title and designator	EPP Course title and designator
Gender gap in science (explicit address)	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below
Women in science (explicit address or role model)	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below
Inquiry-based teaching/learning	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below
Multiple Intelligences approach to teaching/learning	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below
science process skills	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below

	EPP Course title and designator	EPP Course title and designator	EPP Course title and designator	EPP Course title and designator	EPP Course title and designator	EPP Course title and designator
addressing alternative conceptions	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below
Hands-on learning	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below
Science materials for the classroom/science classroom environment	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below
Reading science-based materials	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below
Comfort with science	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below
Confidence with science	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below
Science guest teachers/speakers	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below
Science drawings	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below	See *COURSE NOTATIONS below