EMPOW“HER”ING FEMALE STUDENTS TO PURSUE STEM FIELDS

A Dissertation

by

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ABSTRACT

The focus for this dissertation was on empowering female students to pursue STEM fields. The first study in this dissertation was a content analysis which allowed the researcher to explore the various definitions and surveys used to measure psychological dispositions toward STEM fields to determine a clear definition for each factor. The next two studies used quantitative data from two STEM surveys to investigate whether students' perceptions or self-efficacies were influenced after attending a STEM summer camp. The second study compared female students in two conditions (an all-female and co-educational camp) in order to examine how female students' perceptions were affected by their environment and if these perceptions were correlated to their perception of STEM careers. The third study analyzed participants within the all-female camp to determine if self-efficacy toward STEM fields influenced perceptions of STEM fields and if engagement in an all-female camp had a greater impact for students with lower predispositions toward STEM.

Results from the first study revealed insights into how prior researchers defined and assessed psychological dispositions. These results indicated authors of the selected studies generally opted to offer the definition of the disposition by describing the instrument or providing sample items. The second study's results revealed that female students in the all-female camp experienced a significant increase in their positive perceptions toward science (t=3.568, p<0.001) and there was a strong correlation between STEM perceptions and perceptions of a STEM career. The third study's

findings indicated a significant relationship between female students' initial self-efficacy and perceptions of STEM fields ($p<0.05$). Furthermore, results indicated a statistically significant increase ($p<0.05$) in mathematics perceptions for the below-average group and science perceptions for the average group.

Overall, results from this dissertation study yielded that engagement in a STEM summer camp was conducive for empowering female students to pursue STEM fields by positively improving their self-efficacies and perceptions toward STEM fields. The findings of this dissertation are important because increasing the number of female students pursuing STEM pathways is needed to close the gender gap in STEM fields and fill the need for a diverse STEM workforce in expanding STEM industries.

DEDICATION

This dissertation is first dedicated to the memory of my mother, Violet Kay White, who instilled in me a love of learning, gave me strength growing up, and continuously encouraged me to pursue my dreams. She taught me to never give up and fight for what you want. Second, I dedicate this dissertation to my furbabies, Sophie and Kimber, I hope with the completion of this research, I can one day give them the backyard and pool they deserve. Both of them have supported me throughout my process of completing this research. Finally, I dedicate this research to my friends who became family, along my path to completing my studies. They have supported, encouraged, and motivated me to continue even when times were hard.

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Finally, I would like to thank my dad, sisters, brother-in-law, and sisters-in-laws for visiting me, encouraging me, and always checking on me while I was in school. I would also like to thank Ruben Lopez, who became my rock during the last two years of my journey, he pushed me to ensure I was making progress and was always there to offer his support. Last but not least, I would like to thank Cassidy Caldwell, I do not know where I would be without this amazing person. I know I can count on her for anything and everything, including her personal hot spot, so that I could get my work done while working at various places around town or on our random road trips. She has shown me what true friendship looks like and I look forward to all of our future adventures.

CONTRIBUTORS AND FUNDING SOURCES

Contributors

This work was supervised by a dissertation committee consisting of Dr. Robert M. Capraro [advisor] and Drs. Lynn Burlbaw, Mary M. Capraro, and Jamaal Young of the Teaching, Learning, and Culture Department in the College of Education and Human Development [Home Department] and Dr. Luciana Barroso of the Zachry Department of Civil and Environmental Engineering [Outside Department].

The data analyzed for Chapter 2 was conducted by the student and Drs. Robert M. Capraro, Mary M. Capraro and Jamaal Young. The literature review depicted in Chapter 3 was conducted in part by an undergraduate research team lead by the student, the undergraduates in this team included: Cassidy Caldwell, Erica S. Lohman, and Sabrina Rodriguez. The literature review and analysis in Chapter 4 was conducted by the student with the support of Cassidy Caldwell and Hyunkyung Kwon.

All other work conducted for the dissertation was completed by the student independently.

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NOMENCLATURE

AFC	All-female STEM Summer Camp
D	Definition by default
CFI	Comparative Fit Index
EngPer	Engineering Perceptions
EngSE	Engineering Self-efficacy
I	Definition by induction
MathPer	Math Perceptions
MathSE	Math Self-efficacy
MST	Mathematics, Science, and Technology
NSF	National Science Foundation
O	Operational definition
PBL	Project-based Learning
RMSEA	Root Mean Squared Error of Approximation
SciPer	Science Perceptions
SciSE	Science Self-efficacy
SET	Science, Engineering, and Technology
SJR	Scimago Journal Rank
SMET	Science, Mathematics, Engineering, and Technology
SNIP	Source Normalized Impact per Paper
SRMR	Standardized Root Mean Square

S-STEM	Student Attitudes toward STEM
STEAM	Science, Technology, Engineering, Arts, and Mathematics
STEM	Science, Technology, Engineering, and Mathematics
STEMM	Science, Technology, Engineering, Mathematics, and Medicine

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1. INTRODUCTION

1.1. Statement of the Problem

Despite the gains that women have made in science and engineering fields, they are still underrepresented in various engineering professions (Jayaratne, Thomas, & Trautmann, 2003; National Science Foundation [NSF], 2017). There are three main reasons to focus on promoting women in science, technology, engineering, and mathematics (STEM): a) there is a demand for female STEM professionals in various engineering fields, b) the value of incorporating different viewpoints to promote STEM modernization, and c) to ensure equity in STEM access as our society advances (Ireland et al., 2018). The National Science Foundation (NSF) (n.d.) has made a specific effort to increase women's participation in underrepresented science and technology fields. Many high school females leave high school prepared to pursue science and engineering majors in college, yet choose not to pursue any of these fields (Clewell & Burger, 2002; Demetry et al., 2009; Hill, Corbett, St. Rose, & American Association of University Women, 2010). Furthermore, those women who decided to pursue and graduate with a STEM degree, still chose not to pursue working in fields such as computer science and engineering (Darke, Clewell, & Sevo, 2002). This fact brings to light the following questions: Why are women, who are capable of entering engineering or technology, not choosing careers in these STEM fields? How can we get more women to stay engaged and motivated to pursue male-dominated STEM fields?

1.2. Purpose of the Dissertation

The purpose for this three-article dissertation was to explore factors that influence female students' desires to pursue STEM fields and careers. For this dissertation, I examined female students' perceptions about STEM fields and attempted to determine if they were influenced by the setting of a STEM summer camp (i.e. single-gender vs co-educational). First, I explored the various psychological dispositions (i.e. attitudes, perceptions, affect, and self-efficacy) to lay the ground work for which disposition should be measured in the subsequent two studies. I used data from the *STEM Semantics* and *Student Attitudes toward STEM* (S-STEM) surveys, which were administered the summer of 2017, for the second and third articles. These two surveys provided insight into students' perceptions and self-efficacy toward STEM fields and careers. I compared female students' perceptions in an all-female camp to female students' in the co-educational camp to determine correlations between their perceptions of science, mathematics, and engineering to their desire to pursue a STEM career. Finally, I investigated how female students' perceptions and self-efficacies were influenced after attending an all-female camp.

Results from these articles provide insight into factors that influence interest in STEM fields and careers, as well as provide awareness into female students' perceptions and self-efficacy toward STEM fields. This knowledge can be used to encourage and motivate women to pursue and remain in STEM careers. Therefore, my findings from this three-article dissertation will address the gender gap in STEM fields and careers.

1.3. Literature Review

Women are underrepresented in STEM fields and careers (NSF, 2017), but have made great strides toward narrowing the gap in the late 20th century (Jayaratne et al., 2003). Therefore, special attention has been placed on empowering and engaging women and girls in STEM to encourage them to pursue these fields. Prior research has indicated it is critical to develop science interest as early as the middle of childhood in order to predict interest in science later (Alexander, Johnson, & Kelley, 2012). Early science interest in young female students promotes factors such as positive self-concepts and higher scores in science (Alexander, Johnson, & Leibham, 2015; Leibham, Alexander, & Johnson, 2013). Additionally, parents of young girls, who expressed an interest in science, sought out more opportunities to allow their daughters to participate in science activities than the young female students who did not express an interest in science (Alexander et al., 2012). This proposes that parents are attentive to the gendered stereotypes of STEM fields and support their daughter's science interests by providing these opportunities (Alexander et al., 2012). As these girl's progress through school they are likely to stay engaged and motivated to pursue STEM fields. Therefore, it is important to follow the evolution of STEM education to see what structures have been put in place to encourage and motivate students, specifically females, to pursue STEM fields.

1.3.1. Evolution of STEM Education

The acronym for science, technology, engineering, and mathematics, or STEM, is a big topic of conversation at the moment in education and policy. In spite of the widespread use of the word, educators, researchers, and policy makers have yet to agree on one set definition for STEM. STEM education is the result of a political reaction to needing more skilled workers in STEM fields to ensure the United States' international supremacy (Blackley & Howell, 2015; Breiner, Harkness, Johnson, & Koehler, 2012; Oleson, Hora, & Benbow, 2014). The STEM education initiative is a result of the United States' attempt to fulfill a need of preparing students for the expanding STEM field. Before the use of STEM in education, there were other acronyms employed to identify the evolving fields of mathematics and science (i.e. SET, MST). Science, engineering, and technology (SET) and mathematics, science, and technology (MST) were other variants of STEM, before its official adoption (Wong, Dillon, & King, 2016). In the 1990s, science, mathematics, engineering, and technology (SMET) was the first attempt to bridge all four disciplines together by the NSF (Sanders, 2008). However, SMET quickly evolved into the more commonly used acronym STEM (Breiner et al., 2012; Sanders, 2008; Wong et al., 2016). Other variations of STEM have cropped up (i.e. STEAM, STEMM, etc.), which continues to add to the confusion of determining what is STEM education.

Varying definitions for STEM have been conveyed in prior research. Some argue that STEM is the collection of disciplines that should be taught using traditional methods, whereas others argue for the integration of the four disciplines to mirror their use in the workplace (Breiner et al., 2012; Holmlund, Lesseig, & Slavit, 2018; Wong et al., 2016). This inability to come to a consensus on a definition for STEM (Fraser, Earle, & Fitzallen, 2019; Siekmann & Korbel, 2016), presents an interpretation challenge for educators, researchers, and policy makers (Barkatsas, Carr, & Cooper, 2019; Berry, McLaughlin, & Cooper, 2019; Manly, Wells, & Kommers, 2018). For instance, in a study involving faculty members from various STEM projects, results indicated this group of professionals were unable to agree on a set definition of STEM (Breiner et al., 2012). This field of research needs clarification about what counts as STEM and how these disciplines should be implemented in educational settings (Kloser, Wilsey, Twohy, Immonen, & Navotas, 2018). The "STEM Education Act of 2015" (2015), provided a very broad definition for STEM education:

> For purposes of carrying out STEM education activities at the National Science Foundation, the Department of Energy, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the National Institute of Standards and Technology, and the Environmental Protection Agency, the term ‘‘STEM education’’ means education in the subjects of science, technology, engineering, and mathematics, including computer science (p. 541).

This definition is all encompassing and does not provide teachers, researchers, or policy makers with guidance on how STEM education can be implemented in educational settings. Whereas, other researchers assert STEM education is the interaction between the four disciplines that impact academic practices (Kloser et al., 2018). These two definitions emphasize the spectrum that prior research offers for defining STEM education.

Researchers who define STEM education simply by expanding the acronym, are typically more focused on the individual disciplines, rather than the integration of the disciplines (Manly et al., 2018; Sanders, 2008) This approach to the definition of STEM is more policy oriented and usually implemented through traditional teaching practices

(Breiner et al., 2012). Furthermore, isolating the disciplines from one another causes students to view STEM as only focusing on science and mathematics, despite the fact that technology and engineering impact daily life (Bybee, 2010). Conversely, researchers who envision STEM education as the integration of the four disciplines, focus on specific academic practices that can be implemented to incorporate two or more of the disciplines (Capraro & Jones, 2013; Capraro et al., 2018; Gubbins et al., 2013; Sanders, 2008). Researchers further suggest this definition of STEM views it as one cohesive unit, taught simultaneously, with time for hands-on inquiry and project-based activities, as it is seen in the workplace by STEM professionals (Breiner et al., 2012; Capraro & Jones, 2013; Capraro et al., 2018; Gubbins et al., 2013). Focusing on the integration of STEM as a definition for STEM education provides insight into academic activities that can be incorporated in classrooms.

Moreover, when mathematics and science teachers are interviewed about their perceptions of STEM, they consistently report their dislike for the term STEM (Wong et al., 2016). This could be due to the policy implications that come along with this term and the lack of consensus of what is meant by STEM education (Fraser et al., 2019; Siekmann & Korbel, 2016). While some researchers argue for the need of a formal definition to ensure consistency within STEM education research (Breiner et al., 2012; Kloser et al., 2018; Manly et al., 2018). Breiner, Harkness, Johnson, and Koehler (2012) and Siekmann (2016) exclaim this will compartmentalize efforts. Despite this lack of a formal definition for STEM, educators should realize their perceptions and negative connotations associated with implementing STEM in their classrooms can have consequences on their students' perceptions of these fields.

1.3.2. Empowering Female Students to Pursue STEM Fields

Agencies and programs have made it their mission to empower females to pursue STEM fields. Specifically, the NSF has determined one of their main efforts is to increase the participation of women, minorities, and other underrepresented groups in science and technology (NSF, n.d.). Researchers recognize that intervention strategies have narrowed the gender gap (Clewell & Burger, 2002), but these strategies have not improved equity in STEM fields. Clewell and Burger (2002) argue that the STEM system itself must change to be more accommodating and inclusive for women. One intervention strategy that has been implemented is the use of informal programs (e.g. extracurricular STEM activities, summer camps, activities for parents, and/or professional development for teachers) that focus on improving science literacy, impacting students' motivation, mentoring, or challenging gendered stereotypes (Darke et al., 2002; Jayaratne et al., 2003). These programs promoted short-term and long-term positive changes in cultivating equity in STEM fields (Darke et al., 2002). One intervention used by agencies and programs to promote women in STEM is the use of informal programs that give female students hands-on STEM opportunities.

1.3.3. Factors Influencing Women's Interest in Engineering

There are a multitude of other factors that influence womens' interest and desire to pursue an engineering career, such as: teachers influence, gendered stereotypes, and gender bias. One significant predictor for female students' interest and confidence in science was their science teacher's influence (Heaverlo, Cooper, & Lannan, 2013). Because society, and many educators, still view STEM fields as masculine, these gendered stereotypes inherently trickle down and impact female students, because it discourages them, gives them low confidence, and negative perceptions of their success in STEM careers (Hill et al., 2010; Martin & Beese, 2016; Master, Cheryan, Moscatelli, & Meltzoff, 2017; Yatskiv, 2017). Female students believe they lack comparable skills to their male peers and deem themselves incapable of being successful in STEM fields (Piatek-Jimenez, Gill, & Cribbs, 2018; Savaria & Monteiro, 2017; Wieselmann, Roehrig, & Kim, 2017). In addition, high school females often have negative experiences in STEM courses, which cause them to lose their desire to pursue these fields (Burns, Lesseig, & Staus, 2016). For instance, Hammack and High (2014) reported that males and females experience science activities in different ways, where males are more assertive in hands-on activities and females more accommodating and watchful. For these reasons, male students are four times more likely to enroll in STEM fields than females (Morgan, Gelbgiser, & Weeden, 2013). This underrepresentation is ascribed to the obstacles that many females face, including fear, discouragement, and self-doubt (Robnett & Thoman, 2017; Watt et al., 2017). If females persevere in and pursue STEM disciplines, they report levels of self-efficacy equivalent to their male counterparts in most STEM disciplines. However, they report lower levels in chemistry, computer science, and engineering than their male peers, these fields are where gender gaps become more prevalent (Wilson, Bates, Scott, Painter, & Shaffer, 2015). Female students tend to report significantly lower levels of self-efficacy in chemistry and mathematics, which sometimes results in them deciding not to pursue engineering completely (Wilson et al., 2015). If females are able to overcome these factors that diminish their aspirations for STEM careers and actually graduate with a STEM degree, they are still susceptible to gender bias in the workplace.

Organizations and businesses have maintained that women can be a burden because of their maternal instincts and roles. These biases impact the workplace and deter women from entering or even staying in these fields (Fouad, Singh, Cappaert, Chang, & Wan, 2016; Xu, 2015; Yatskiv, 2017). Many women state they received little or no support from their supervisors when attempting to balance their home and work lives (Fouad et al., 2016; Xu, 2015; Yatskiv, 2017). Furthermore, women begin to feel separated from their female identity and STEM identity and will sometimes distance themselves from conventional female traits in an attempt to fit into the male-dominated fields (Piatek-Jimenez et al., 2018). Women also report lower salaries when compared to their male counterparts in similar fields and positions (Xu, 2015). All of these factors attribute to women's low representation in STEM, specifically engineering fields. Researchers need to determine sound educational practices that can be implemented in order to empower women to persevere in STEM fields.

1.4. Research Questions

The subject of this dissertation focused on exploring female students' perceptions and STEM self-efficacies in order to attempt to determine factors that will motive female students to pursue and endure in these high need areas. The following three questions guided the research for the three articles for my dissertation.

1. How are the words: attitudes, affect, perceptions, and self-efficacy, used in STEM educational research?
    a. What is the most common agreed upon definition of each psychological disposition in STEM education research?
    b. How do the definitions or items found in previous STEM education studies align to the conceptually based psychological definitions?
2. How does engagement in STEM project-based learning (PBL) activities, in single-gender classes compare to co-educational classes, affect female students' perceptions of science, mathematics, and engineering?
    a. How do female students' perceptions of science, mathematics, and engineering affect their perceptions of a STEM career?
3. How does engagement in an all-female STEM summer camp influence female students' mathematics and science self-efficacies and perceptions of STEM fields?
    a. Does a single-gender camp have a greater impact on female students' self-efficacies and perceptions of STEM fields for students with initial below-average, average, or above-average STEM perceptions?

1.5. Methods

The quantitative methods used for the three articles were different based on the research question for each study. A content analysis was conducted for the first article. That first article focused on psychological dispositions that influence student achievement. In the second and third articles, Cohen's *d* effect sizes, confidence intervals, and t-tests were used to analyze the differences between pre- and post-test results. The second article used regression and correlational analyses by subscale (science, mathematics, and engineering) and by camp type (all female camp or females in co-educational camp) to determine the relationship between each subscale and perceptions of a STEM career. The third article implemented a path analysis to determine if there was a relationship between STEM perceptions and mathematics and science self-efficacies.

1.6. Journal Selection

For each article, I selected two potential journals for publication. These journals were first selected based on articles cited in my literature review. Next, the description and purpose of each of these journals were reviewed to determine if the articles were appropriate for the journal. Finally, I reviewed the impact factors and the editorial board of each journal to ensure the journals were the best for my research. The *Scimago Journal Rank* (SJR) and the *Source Normalized Impact per Paper* (SNIP) were the factors used to determine the impact of these journals. These factors and information about the journal (i.e. acceptances rates, review type, and manuscript lengths) were found using *Cabell's Directory of Publishing Opportunities*, *Journal Citation Reports: Science and Social Sciences*, *Scimago Journal and Country Rank,* and *Scopus*. Table 1.1 lists two potential journals, with accompanying journal information, for each article. The two potential journals selected were appropriate and well suited for each respective article.

Table 1.1. Articles and Potential Journals

Article	Potential Journal #1	Potential Journal #2
Article 1: Attitudes, Perceptions, Affect, and Self-efficacy… Oh my: What am I measuring?	*Psychological Bulletin* • Acceptance rate: 12% • Impact and ranking (SJR/SNIP): 9.276/8.23 • Editor in Chief: Blair T. Johnson • Publisher: American Psychological Association • Type of review: Double Blind Peer-review • Manuscript length: n/a • *Article is under review (submitted on 05/21/2020)*	*International Journal of Science and Mathematics Education* • Acceptance rate: 30% • Impact and ranking (SJR/SNIP): 0.737/1.072 • Editor in Chief: Huann-shyang Lin • Publisher: Springer • Type of review: Double Blind Peer-review • Manuscript length: 30 pages
Article 2: Female Students' P"her"ceptions of STEM Disciplines and Careers	*International Journal of Science Education* • Acceptance rate: 32% • Impact and ranking (SJR/SNIP): 0.906/1.388 • Editor in Chief: Jan van Driel • Publisher: Taylor & Francis • Type of review: Double Blind Peer-review • Manuscript length: 8500 words • *Article is under review (submitted on 12/13/2019)*	*International Journal of Science and Mathematics Education* • Acceptance rate: 30% • Impact and ranking (SJR/SNIP): 0.737/1.072 • Editor in Chief: Huann-shyang Lin • Publisher: Springer • Type of review: Double Blind Peer-review • Manuscript length: 30 pages
Article 3: Too Few Women: Fostering Adolescent Female Students' Positive Perceptions and Self-Efficacy in STEM Fields	*Journal of Women and Minorities in Science and Engineering* • Acceptance rate: n/a • Impact and ranking (SJR/SNIP): 0.848/0.671 • Editor in Chief: Julie Martin • Publisher: Begell House • Type of review: Peer-Review • Manuscript length: No limit • *Article is under review (submitted on 3/16/2020)*	*Science Education* • Acceptance rate: 11% • Impact and ranking (SJR/SNIP): 2.240/2.355 • Co-editors: Sherry A. Southerland & John Settlage • Publisher: Wiley • Type of review: Double Blind Peer-review • Manuscript length: 26-30 pages

Note: SJR: *Scimago Journal Rank* in 2017; SNIP: *Source Normalized Impact per Paper* in 2017

2. ARTICLE 1: ATTITUDES, PERCEPTIONS, AFFECT AND SELF-EFFICACY… OH MY: WHAT IS BEING MEASURED?

2.1. Introduction

Student's desire to learn, participate, and choose careers in science, technology, engineering, and mathematics (STEM) rely on their attitudes and beliefs in these subjects, as well as their self-efficacy in those subjects (Markovits & Forgasz, 2017). These psychological dispositions and others, such as affect, perceptions, interest, and motivation have been evaluated extensively to determine their impact on students' achievement (e.g. Campbell et al., 2014; Clark et al., 2014; Foster, 2016; Lewis, 2015; Markovits & Forgasz, 2017). Yet, students' STEM achievement scores remain low across the country. As researchers continue to search for strategies, interventions, and factors that will help improve these scores, a retrospective review of the common definitions and utilizations of STEM related psychological definitions is warranted.

Many of psychological dispositions, or factors, are used interchangeably throughout research (Lee & Francis, 2018). Therefore, there is confusion among researchers about the measurement of these factors, due to: a) the broad range of research about these topics, b) the varied use of these words, c) the lack of consensus for the definition, and d) the differences between these words (Luo, Wei, Ritzhaupt, Huggins-Manley, & Gardner-McCune, 2019; McDonough & Sullivan, 2014; Moyer, Robison, & Cai, 2018; Sharpe, Abrahams, & Fotou, 2018; Thibaut, Knipprath, Dehaene, & Depaepe, 2019). Despite the lack of a clear definition, there is consensus across the literature that these factors are molded by the students' individual experiences throughout their lives (Clark et al., 2014; Markovits & Forgasz, 2017; Moyer et al., 2018). Thus, addressing this confusion is paramount to improved teaching, learning, and experimentation with STEM education disciplines.

2.2. Purpose Statement

The purpose of this study is to review the definitional and measurement alignment surrounding the conceptual definitions of four dispositions within STEM education literature (i.e., affect, attitude, perception, and self-efficacy). These four constructs are arguably the most commonly used and misused descriptors of dispositions within STEM education research literature. The importance of these constructs to the STEM education disciplines is evidenced by the numerous systematic reviews synthesizing the research surrounding each construct (Margot & Kettler, 2019; Regan & DeWitt, 2015; Sheu et al., 2018). However, the empirical merit of these constructs can be undermined if they are not accurately operationally and theoretically defined within the published research. Thus, this current study has the potential to bring consensus among educational researchers by encouraging them to provide a clear definition of this disposition set (i.e., attitudes, perceptions, self-efficacy, and affect) in the context of their study and list sample items which measure the intended psychological disposition.

2.3. Literature Review

STEM educational researchers have studied the impact of students' psychological dispositions, such as attitudes, self-efficacies, interests, and perceptions, on their academic achievement and career interests. These dispositions have been used interchangeably and were at times used without clear definitions or descriptions, making the research associated with these psychological dispositions difficult to differentiate between and clearly measure. Each of these dispositions will be explored through a conceptually based educational psychological lens to summarize prior research and definitions used to measure these dispositions. Given the interrelationships and documented confusion amongst these dispositions, a concept map illustrating the connections between each construct is provided in Figure 2.1 below.

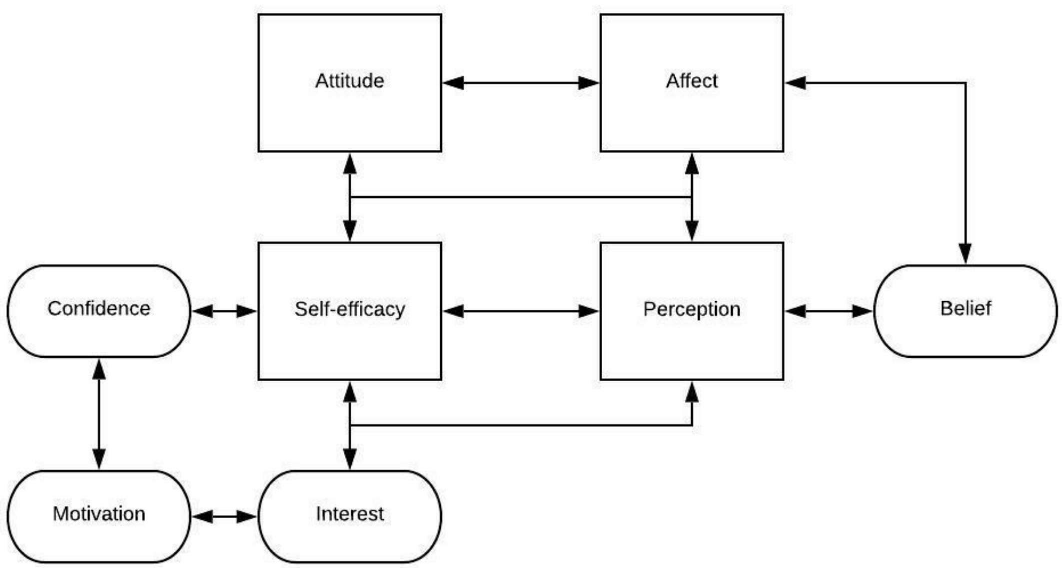


Figure 2.1 Psychological Dispositions Concept Map

Figure 2.1 represents these relationships based on prior research and indicates how the words were associated with one another. Each line in this figure represents the relationship between the two words. Because of the complexity of the relationships seen in the figure and highlighted in prior research, it is understandable why these dispositions are closely linked to one another and often lack clarity when presented in research. As illustrated in this figure, one can see that attitudes are directly influenced by and impacts affect and self-efficacy. Likewise, interest ultimately impacts attitudes, because a students' interest will impact self-efficacy, which directly impacts attitude. This concept map allows one to see each of the dispositions' impact on the other psychological dispositions that are typically measured within attitudinal research. In the sections that follow, these interrelationships are further explicated.

2.3.1. Attitudes

Attitudes are a psychological inclination that is determined by evaluating an object based on an individual's degree of like or dislike toward that object (Ajzen & Fishbein, 1980; Eagly & Chaiken, 1993; Rosenberg & Hovland, 1960). Researchers have argued that attitudes cannot be observed or measured because attitudes were predispositions toward an object, alternatively researchers argue that attitudes were inferred from how an individual reacts to the object (Rosenberg & Hovland, 1960). According to the APA College Dictionary of Psychology, "attitudes provide summary evaluations of target objects and are often assumed to be derived from specific beliefs, emotions, and past behaviors associated with those objects" (VandenBos, 2016, p. 34). These three constructs (beliefs, emotions, and past behaviors) have been known to help form and alter a students' attitude (Albarracin, Johnson, Zanna, & Kumkale, 2005; Rosenberg, 1960). Likewise, attitudes have a mutual impact on a person's affect, beliefs, and behaviors. The difference is attitudes are evaluative and can be inferred from and influenced by beliefs, affect, and behavior (Albarracin et al., 2005; Fazio, 1986; Fishbein & Ajzen, 1975; Schwarz & Bohner, 2001). Furthermore, attitudes may change based on this give and take between these three constructs, socialization, and exposure to new information (Albarracin et al., 2005). Prior research has reported that an individual may not always report the same attitude toward an object, especially if asked about it in different contexts on more than one occasion (Krosnick, Judd, & Wittenbrink, 2005). Attitudes were not merely evaluative for inclination toward an object, but also served as a factor for specific actions (Clore & Schnall, 2005; Rosenberg & Hovland, 1960). Attitudinal research has been extensive and includes a multitude of dispositions, such as affect, interest, beliefs, motivation, confidence to be measured within the studies, which has caused many varying definitions to be created. For the purpose of this study, attitudes are determined by evaluating a person's inclination toward an object, informed reciprocally by their affect, beliefs, and behaviors.

2.3.2. Affect

Affect is influenced by and influences a person's attitudes, it is based conceptually on the literature centered around emotion (Schimmack & Crites, 2005). Affect became an established concept within attitudinal research around the 1960s (Albarracin et al., 2005). Many times, affect is used as a broad term to encompass all emotional and motivational constructs that do not fit neatly under cognitive structures (Eagly & Chaiken, 2005). Affect involves a person's feelings they experience toward an object. In turn, these feelings are determined by their emotions, senses, and moods (Berkowitz, 2000; Schimmack & Crites, 2005). Affect indicates whether a person likes or dislikes an object (Clore & Schnall, 2005; Krosnick et al., 2005). Because affect was initially defined as the evaluation or appraisal of an object based on emotions, researchers equated affect with attitudes (Giner-Sorolla, 1999). Both affect and attitudes are evaluative, but emotions (affect) are momentary, so their judgements are controlled by time, while attitudes are not limited by time and are more long-term judgements (Clore & Schnall, 2005). However, affect differs from attitudes in that one can have a particular feeling toward an object without necessarily evaluating it (Albarracin et al., 2005). Affect is a powerful basis for a person's attitudes (Wyer & Srull, 1989). For instance, a satisfying taste of chocolate ice cream (affect) provides information about a person's attitudes toward chocolate and ice cream. Previous researchers found that emotions and senses had a stronger impact on attitudes than a person's moods (Schimmack & Crites, 2005). Furthermore, prior research has shown that people were more judgmental about an object when they experienced a negative affect toward the object when compared to a positive affect toward the object (Schwarz & Clore, 1996; Worth & Mackie, 1987). This prior research aligned with the definition provided in the APA College Dictionary of Psychology, which defined affect as "any experience of feeling or emotion, ranging from suffering to elation, from the simplest to the most complex sensations of feeling, and from the most normal to the most pathological emotional reactions" (VandenBos, 2016, p.10). In summary for the purpose of this study, affect measures a person's feelings toward an object, are typically short-lived, and non-evaluative, furthermore, one's affect is influenced and influences a person's attitudes.

2.3.3. Self-efficacy and Confidence

Self-efficacy is one's confidence in their own abilities. According to the APA College Dictionary of Psychology, self-efficacy was defined as "an individual's subjective perception of his or her capability to perform in a given setting or to attain desired results" (VandenBos, 2016, p. 427). This definition was centered around Albert Bandura's research. Bandura's (1986) work in social cognitive theory defined self-efficacy as "the belief in one's capabilities to organize and execute courses of action required to produce desired attainments" (p. 391). More specifically, self-efficacy has been used as a situational term, and been defined as one's confidence to be successful in completing a specific task (Carberry, Lee, & Ohland, 2010; Coopersmith, 1967; Hackett & Betz, 1989; Sherer et al., 1982). Therefore, Bandura (2006) argued that surveys intended to measure self-efficacy must be tailored to the specific activity or domain to ensure accurate measurement of the disposition. In other words, self-efficacy surveys measured a students' confidence in their ability to successfully complete a task or do well in a specific subject (Blotnicky, Franz-Odendaal, French, & Joy, 2018; Coopersmith, 1967; Diegelman & Subich, 2001; Lent, Brown, & Larkin, 1986; Zimmerman, 2000). Self-efficacy has been linked reciprocally to students' interest and perception of that subject (Bandura, 1986; Bong, Lee, & Woo, 2015; National Academy of Engineering & National Research Council, 2014). Additionally, prior research indicated self-efficacy had a strong relationship with academic performance and career interest (Bandura, 1986; Richardson, Abraham, & Bond, 2012). Based on this prior research, for the purpose of this study, self-efficacy and confidence are linked together to measure a student's confidence in their abilities.

2.3.4. Perceptions and Beliefs

Perceptions and beliefs are closely related concepts that influence one another. Because perceptions are interpretations of information, perceptions influence a person's beliefs about a given object (Wyer & Albarracin, 2005). The definition for perceptions in the APA College Dictionary of Psychology stated perceptions were "the process or result of becoming aware of objects, relationships, and events by means of the senses, which includes such activities as recognizing, observing, and discriminating" (VandenBos, 2016, p. 327). A person's beliefs are formed from their personal experiences, these beliefs resulted from observing the world around them, implicitly accepting information from other individuals, or making inferences based on their own experiences (Ajzen & Fishbein, 1980). Prior research indicated that when reviewing the structure of attitudes, attitudes could be defined as beliefs (Albarracin et al., 2005; Kruglanski & Sroebe, 2005; Wyer & Albarracin, 2005). However, most beliefs can be verified, but not all attitudes can be verified (Eagly & Chaiken, 1993). For instance, if someone was asked to give reasons for liking or disliking something, they would generate a list of statements (beliefs) that could be verified and then would alter their attitudes to align with those reasons (Tessler, 1978; Wilson, Dunn, Kraft, & Lisle, 1989). Expectancy-value theoretical models emphasized that beliefs influenced attitudes (Carlson, 1956), however, other researchers assert there is a bi-directional relationship between attitudes and beliefs (Marsh & Wallace, 2005). For the purpose of this study, perceptions refer to how one interprets the world around them based on their prior experiences.

2.3.5. Interest and Motivation

Interest and motivation have not been specifically linked to attitudes like affect, self-efficacy, and perceptions. However, these two factors impact students' attitudes toward STEM fields. Interest is an emotion that is connected to being curious and looking for information and is believed to stimulate involvement (Fayn, Silvia, Dejonckheere, Verdonck, & Kuppens, 2019; Fredrickson, 1998; Silvia, 2005; Tomkins, 1962). Interest can be measured by one's desire to pursue an object, which is subjectively based on their beliefs and affect, and ultimately their attitude toward the object. Finally, motivation is influenced by a person's desire to reach a specific goal (Eagly & Chaiken, 2005). Motivation can also be impacted by a person's confidence and interest in an object. While interest and motivation may not be specifically linked to attitudes, these two constructs are ultimately influenced by one's attitudes.

Prior research has highlighted the overlapping relationships between psychological dispositions such as attitude, affect, self-efficacy, and perception. Furthermore, researchers have mentioned the lack of consensus among research concerning these factors (Clark et al., 2014; Markovits & Forgasz, 2017), which has caused confusion among researchers when measuring these dispositions.

2.4. Methods

Psychological dispositions are commonly measured within STEM educational research to determine their impact on academic achievement and STEM career interest. A content analysis was conducted in order to make sense of the various definitions and surveys used to measure the psychological dispositions and determine if their uses are aligned with the conceptual definitions (see Table 2.1). This type of analysis is appropriate because a content analysis "refers to any qualitative data reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings" (Patton, 2014, p. 541). Through this study we will address the following research question by looking for patterns and themes within prior research. How are the words: attitude, affect, self-efficacy, and perception used in STEM educational research? Specifically, we will also examine two sub-questions that allow a nuanced unpacking of how definitions drive research.

1. What is the most common agreed upon definition of each psychological disposition in STEM education research?
2. How do the definitions or items found in previous STEM education studies align to the conceptually based psychological definitions?

Table 2.1 Psychological Disposition Definitions

Psychological Disposition	Conceptual Definition
Attitude	a person's evaluative inclination toward an object based on the person's determination to like or dislike the object
Affect	a person's feelings toward an object and are typically short-lived
Perception	a person's awareness based on integration of their experiences
Self-efficacy	a person's self-perceptions, or confidence, of their abilities

2.4.1. Inclusion Criteria and Search Procedures

A rapid review was conducted as a pilot study, to inform the final search and inclusion criteria protocols for the current study. Search criteria were implemented in three main databases (ERIC, Educational Source, and PsychINFO) which were used to systematically search for published articles that measured one of the dispositions (affect, attitude, perception, self-efficacy) within STEM educational research between 2014-2019. This timeframe was selected because of the recent spotlight on STEM education to increase the number of skilled STEM workers. One member of the research team in the current study searched each of the databases using Boolean/Phrase search modes, for relevant studies with the following search terms in either the title (TI), abstract (AB), or used as descriptors (DE): perception* OR affect* OR self-efficacy* OR attitude* AND STEM Education AND Secondary Education AND student*. The asterisk was used in each of the databases to return any articles that began with the stem word listed. Additionally, the researcher used the thesaurus in each of the databases to ensure that all relevant synonyms were included in the searches. The results in each database were limited to "academic journals" and "English." The searches resulted in 379 articles from ERIC, 281 articles from Education Source, and 105 articles from PsychINFO (see Figure 2.2). This resulted in a total of 765 potential articles, which were imported into Excel and duplicates were removed for a final total of 441 potential articles. The researcher then created conditional formatting rules to highlight the title or abstract a certain color if it contained one of the four dispositions. The articles were then separated into four tabs, one for each of the psychological dispositions: 83 articles were initially coded as measuring affect, 99 articles coded as measuring attitude, 167 articles coded as measuring perception, and 92 articles coded as measuring self-efficacy.

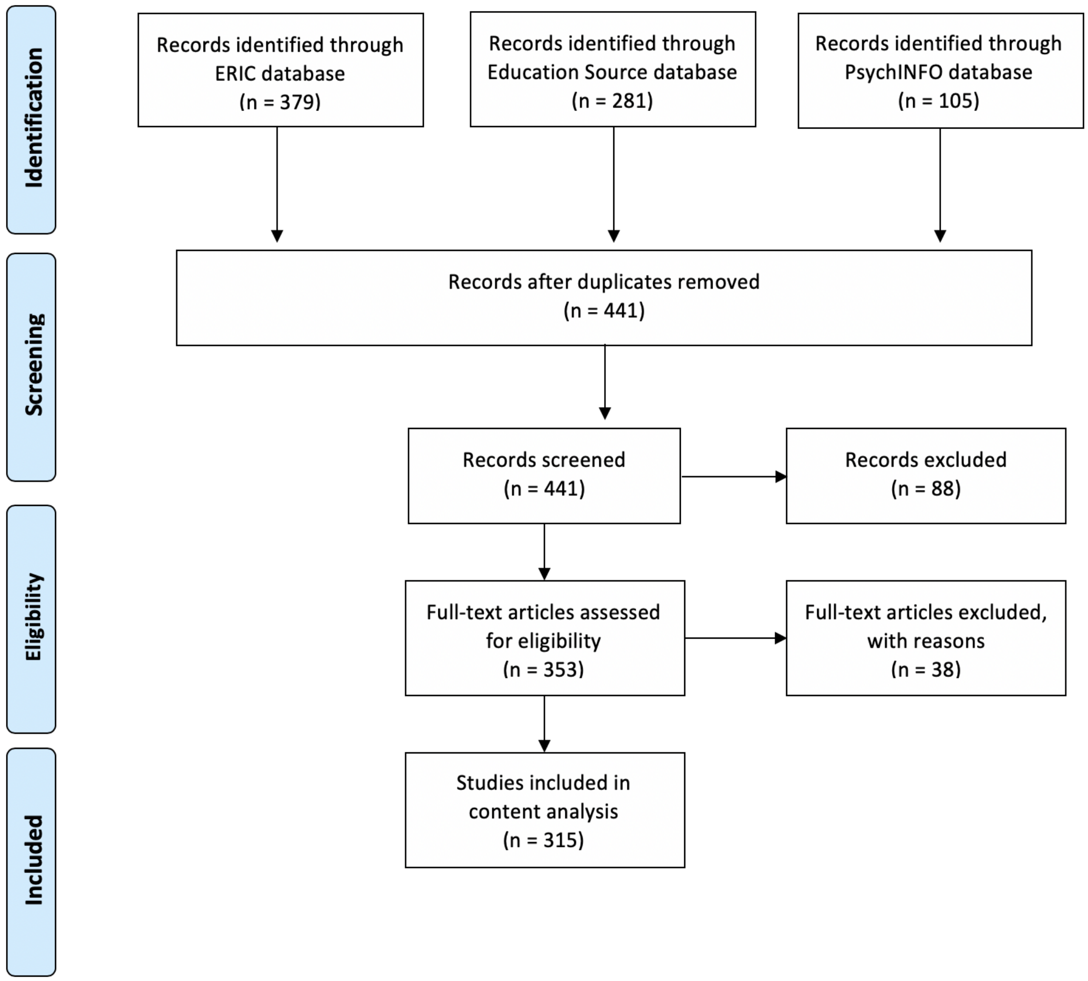


Figure 2.2 Flow Diagram for Content Analysis Inclusion

2.4.2. Coding Procedures

Next, each researcher was assigned a disposition and independently read the abstract of each study to determine initial eligibility. This initial eligibility included or excluded articles based on whether or not the title or abstract indicated one of the desired psychological dispositions was measured. Eighty-eight articles were excluded after this first round of eligibility. The research team then met to develop the coding protocol, coding form, and came to a consensus on the coding method. Next, researchers independently retrieved each of their assigned articles and completed the coding form.

The following information was gathered on the coding form: APA citation, year, abstract, purpose, location (international or United States), participants (K-12 students, teachers, college student, and/or other), STEM content examined (science, technology, engineering, mathematics, STEM and/or computer science), disposition examined (affect, attitude, perception, and/or self-efficacy), focus of the disposition (content, context, and/or career), research approach (quantitative, qualitative, or mixed methods), construct measurement (survey, observation, interview, and/or other), description of disposition measured, operational definition of disposition, and survey description and/or items, the coder's rationale for whether or not the disposition was aligned to the conceptual definition based on the description, operational definition, and/or survey description and/or items provided by the authors. Several categories (participants, STEM content examined, disposition examined, focus of the disposition, and construct measurement) allowed researchers to check all that apply. Therefore, any article that included more than one disposition, all dispositions that were measured were selected or if a study included different participants then all that applied were selected. For instance, if a study assessed students' self-efficacy and perception, then both of these dispositions were selected on the form. Or if one study assessed K-12 students and teachers' attitudes, then K-12 students and teachers were selected under participants.

During this second round of eligibility, 38 articles were excluded because they did not meet the inclusion criteria, resulting in a total of 315 articles included for the analysis. The inter-rater agreement for coding articles was 87.1% ($\kappa = 0.72$), researchers compared completed forms and discussed agreement until 100% agreement was reached on coding results. While there were 315 articles included in the analysis, because researchers were interested in how each disposition was measured, they separated the articles that measured more than one disposition into different entries. This resulted in a total of 370 coded entries used for the analysis.

2.4.3. Analysis

Researchers analyzed summary statistics from each coded article to calculate the frequency and percentage of articles based on the year published, location, participants, STEM content examined, disposition examined, focus of the disposition, research approach and construct measurement. Because researchers could select all that apply for participants, STEM content examined, focus of the disposition, and construct measurement, the total percentages for these categories are over 100%. Next, articles were coded into three new codes depending on how the author's provided evidence the disposition was aligned to the conceptual definitions (see Table 2.2). The first code, O, was used when the authors provided the *operational definition* of the disposition within their study and defined its measurable attributes (Patton, 2014). The second code, I, was used when the authors defined the physiological definition using prior research or theoretical underpinnings, this was determined to provide the *definition by induction*. Not to be confused with the inductive approach seen in qualitative research, where researchers review collected information and develop theories (see Patton, 2014). We use induction in the sense of inductive reasoning or logical thinking, where researchers rely on prior studies or theoretical frameworks to determine their definition of the disposition being observed. The third code, D, for *definition by defaul*t, was used when an operational definition or description of the disposition was not provided, and alignment to the conceptual definition was based exclusively on the survey description or measurement items used to assess the disposition within the study. Some studies could have multiple codes based on the information provided by the author, for instance, a study could provide the operational definition and a description of the disposition, so this study would be coded as an O and an I. Researchers then used grounded theory (Strauss & Corbin, 1998) techniques and procedures when analyzing three categories, *operational definition, definition by induction, or definition by default* to look for patterns and themes to determine how the disposition was used within the study and if there was an agreed upon definition between the studies. Finally, entries for each disposition were organized by whether or not the dispositions were aligned to the conceptual definitions based on information provided by the author of each study and the rationale provided by the coder.

Table 2.2 Code for Disposition Aligned by Operational Definition, Induction, or Default

Code	Description	Example
Operational Definition (O)	authors provided the operational definition of the disposition within their study and defined its measurable attributes	"In this paper, we use the term, attitude, to indicate whether a person approves or disapproves with a particular biotechnology application" (van Lieshout & Dawson, 2016, p. 330).
Induction (I)	authors defined the physiological definition using prior research or theoretical underpinnings	"Bandura (1995) described self-efficacy as "the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations" (p. 2)" (DeCoito & Myszkal, 2018, p. 488).
Default (D)	authors did not provide an operational definition or description of the disposition; alignment to the conceptual definition was based exclusively on the survey description or measurement items used to assess the disposition within the study	"The DET is a rubric-style checklist that has been developed to quantify the appearance (gender, color, etc.) and location of engineers in students' drawings, … as a tool to more fully evaluate young students' perceptions of who engineers are and what they actually do (Hirsch, Berliner-Heyman, & Cusack, 2017, p. 400).

2.5. Results

2.5.1. Summary Descriptive Statistics

The attributes for each of the 370 coded entries were presented in Table 2.3. With regard to the distribution of the disposition, affect was underrepresented and accounted for only 3.51% of the selected studies. When reading the abstracts to determine eligibility for the current study, affect was most typically used as a verb rather than as a noun measuring emotion, causing the study to be excluded for analysis. Affect used as a noun was more common from 2016 through 2019 and only used once as a noun prior. The other three dispositions were well represented with attitudes accounting for 30.81%, perceptions accounting for 39.46%, and self-efficacy being represented in 26.22% of the studies. The articles were reasonably spread out between 2014 and 2019. Most of the studies were conducted within the United States (64.05%). K-12 students were used as participants in 80% of the selected studies, more specifically within the attitude studies, K-12 students were the participants in over 90% of the studies. Additionally, over 50% of the studies focused on integrated STEM content across the psychological dispositions, with science content being examined the second highest (32.870%). Despite the passing of the STEM Act in 2015, which added computer science as a component to STEM, it was underrepresented in the studies, only accounting for 3.24% of selected studies. Additionally, focusing specifically on technology or engineering content was also underrepresented, with both of these areas accounting for less than 10% of the studies. More than half of the studies focused on assessing students' dispositions toward the STEM content (52.97%). Conversely, within the perceptions and self-efficacy dispositions, researchers focused more on assessing students' perceptions or self-efficacy within the context of STEM. For instance, researchers measured students' self-efficacy in doing activities during a summer camp or assessed whether students' perceptions were altered after learning about STEM during a summer camp. Finally, the majority of the studies were quantitative (59.46%) and a survey was used most frequently to assess students' dispositions. Specifically, surveys were used in over 90% of the studies assessing attitude, affect, and self-efficacy. While perceptions also heavily relied on quantitative analysis and surveys to assess students, the researchers assessing this disposition relied on qualitative analysis and interviews more when compared to the other dispositions.

Table 2.3 Summary Statistics of Selected Studies

Category	Attitude (*n* = 114)	Affect (*n* = 13)	Perception (*n* = 146)	Self-efficacy (*n* = 97)	Total (*N* = 370)
Year Published	# (%)	# (%)	# (%)	# (%)	# (%)
2014	8 (7.08)	1 (7.69)	17 (11.64)	12 (13.27)	38 (10.27)
2015	9 (7.96)	- (0.00)	21 (14.38)	11 (11.22)	41 (11.08)
2016	25 (22.12)	4 (30.77)	19 (13.01)	11 (11.22)	59 (15.95)
2017	20 (17.70)	2 (15.38)	34 (23.29)	20 (20.41)	76 (20.54)
2018	24 (21.24)	4 (30.77)	23 (15.75)	22 (22.45)	73 (19.73)
2019	28 (24.78)	2 (15.38)	32 (21.92)	21 (21.43)	83 (22.43)
Location					
United States	70 (61.95)	7 (53.85)	92 (63.01)	68 (69.39)	237 (64.05)
International	44 (38.94)	6 (46.15)	54 (36.99)	29 (29.59)	133 (35.95)
Participants					
K-12 Students	103 (91.15)	10 (76.92)	105 (71.92)	78 (79.59)	296 (80.00)
Teachers	13 (11.50)	1 (7.69)	35 (23.97)	8 (8.16)	57 (15.41)
College Student	15 (13.27)	3 (23.08)	22 (15.07)	21 (21.43)	61 (16.49)
Other	7 (6.19)	- (0.00)	11 (7.53)	3 (3.06)	21 (5.68)
STEM Content Examined					
Science	38 (33.63)	2 (15.38)	49 (33.56)	32 (32.65)	121 (32.70)
Technology	10 (8.85)	1 (7.69)	13 (8.90)	9 (9.18)	33 (8.92)
Engineering	10 (8.85)	1 (7.69)	10 (6.85)	10 (10.20)	31 (8.38)
Mathematics	18 (15.93)	3 (23.08)	17 (11.64)	15 (15.31)	53 (14.32)
STEM	58 (51.33)	7 (53.85)	78 (53.42)	54 (55.10)	197 (53.24)
Computer Science	5 (4.42)	- (0.00)	4 (2.74)	3 (3.06)	12 (3.24)
Focus of the Disposition					
Content	89 (78.76)	9 (69.23)	51 (34.93)	47 (47.96)	196 (52.97)
Context	20 (17.70)	2 (15.38)	76 (52.05)	60 (61.22)	158 (42.70)
Career	19 (16.81)	3 (23.08)	39 (26.71)	15 (15.31)	76 (20.54)
Research Approach					
Quantitative	69 (61.06)	9 (69.23)	66 (45.21)	76 (77.55)	220 (59.46)
Qualitative	11 (9.73)	2 (15.38)	41 (28.08)	6 (6.12)	60 (16.22)
Mixed-Methods	34 (30.09)	2 (15.38)	39 (26.71)	15 (15.31)	90 (24.32)
Construct Measurement					
Survey	108 (95.58)	12 (92.31)	112 (76.71)	91 (92.86)	323 (87.30)
Observation	12 (10.62)	2 (15.38)	24 (16.44)	1 (1.02)	39 (10.54)
Interview	26 (23.01)	2 (15.38)	53 (36.30)	11 (11.22)	92 (24.86)
Other	8 (7.08)	1 (7.69)	28 (19.18)	5 (5.10)	42 (11.35)

2.5.2. Attitude

Attitudes were measured in 114 of the selected studies and the majority of these studies administered a survey (95.58%) to assess attitudes toward the content (78.76%) of STEM. Authors of the selected studies relied heavily on the definition by default, as it was the only definition provided in 86 of these studies, while only 13 studies provided the definition of attitude using at least two different methods, and eight studies provided either the operational definition or definition by induction (see Table 2.4). In seven of the studies, the authors did not provide an operational definition or a definition by default or induction, or even more interesting the author may have included the disposition in the title, but then attitude was not measured nor mentioned throughout the paper.

2.5.2.1. Operational Definition

The operational definition was provided in only five of the selected studies. Between these five operational definitions, three of them were similar and indicated that attitudes were a combination of a students' self-efficacy and expectancy-value beliefs (Hsu, Lee, Ginting, Smith, & Kraft, 2019; LaForce, Noble, & Blackwell, 2017; Unfried, Faber, Stanhope, & Wiebe, 2015). A fourth one measured attitude based on a students' interest, perception, and choice of future field of study (Torras Melenchón, Grau, Font Soldevila, & Freixas, 2017). The fifth operational definition, was simply indicating if a person approved or disapproved of a particular application (van Lieshout & Dawson, 2016). Because an operational definition was only provided 5 times out of 114, one cannot identify a common definition for attitude. Additionally, several authors of the selected studies (e.g. Hillman, Zeeman, Tilburg, & List, 2016; Luo et al., 2019; Michael & Alsup, 2016; Thibaut et al., 2018; 2019; Wu, Deshler, & Fuller, 2018) agreed there were too many definitions for attitudes in the literature and there was no common definition.

2.5.2.2. Definition by Induction

Authors of the selected studies relied on prior research or theoretical underpinnings in 18 of the selected studies for attitude. Eagly and Chaiken (1993), Fishbein and Ajzen (1975)and Kind, Jones, and Barmby (2007) were the most frequently cited (14 times) when providing the definition of attitudes. Eagly and Chaiken (1993) and Fishbein and Ajzen (1975) defined attitudes as a psychological tendency expressed by evaluating something either in favor or disfavor toward the object. Kind et al. (2007) discussed attitudes as the strength of an emotion shaping a person's outlook on an object. A few studies cited Eccles & Wigfield's (2002) definition of attitude as being composed of two important subcategories, self-efficacy and expectancy-value beliefs. This last definition diverges from the conceptual definition of attitude, which focuses on a person's evaluative inclination toward an object based on their like or dislike of the object.

2.5.2.3. Definition by Default

Over 80% of the selected studies provided the definition by default, by providing a description of the instrument used or providing sample items which assessed attitude. There were over 60 different surveys or attitude scales administered within the 114 studies, the breadth of the surveys is indicative of the lack of a clear definition or measurement tool to measure attitudes. Thirty of these surveys did not provide a specific name and were mostly created by individual author's adapted from other published attitudinal scales. The survey that was administered most frequently was the *Student Attitudes toward STEM Survey (S-STEM)* which measured students' attitudes and their self-efficacy, but results were typically reported as assessing students' attitudes. Most of the surveys that were intended to measure attitudes, measured other dispositions as well, highlight the fact that many studies used attitudes as a broader term, which encompassed subscales of other psychological dispositions. Some additional surveys that measured students' attitudes included the *Test of Science Related Attitudes (TOSRA)*, *Mathematics Attitude Questionnaire*, and the *Attitude Toward Science Scale*.

2.5.2.4. Alignment to the Conceptual Definition

Overall, in only 25 of the 114 (21.93%) selected studies, the author's measured attitudes in line with the conceptual definition. Seventy-four of the selected studies were not aligned with the conceptual definition and were more apt to use a definition which included other psychological dispositions (i.e., perceptions, self-efficacy) to assess attitudes, using attitudes in a more general or all-encompassing sense. Therefore, the most commonly agreed upon definition for attitudes includes two main factors, a students' self-efficacy and their expectations for success. While this definition may not align with the conceptual definition, it was used frequently throughout the selected studies.

Table 2.4 Attitude Alignment by Type of Definition Provided

Definition by	Frequency	Percentage	Examples
Operational Definition	2	1.75%	“In this paper, we use the term, attitude, to indicate whether a person approves or disapproves with a particular biotechnology application” (van Lieshout & Dawson, 2016, p. 330).
Induction	6	5.26%	“Attitude can be defined as a “general positive or negative feeling toward something” (Koballa & Crawley, 1985, p. 225)” (Diaz, 2019, p. 576)
Default	86	75.44%	Sample Items from *TOSRA*: I would enjoy visiting a science museum at the weekend. I am curious about the world in which we live. I like to listen to people whose opinions are different from mine. A job as a scientist would be interesting. (Price, Kares, Segovia, & Loyd, 2019, p. 244)
Induction & Default	10	8.77%	
Operational Definition & Default	1	0.88%	
Operational Definition, Induction, & Default	2	1.75%	
N/A	7	6.14%	Attitude mentioned in abstract and introduction, but not used within the text of the article

2.5.3. Affect

One's affect was assessed by researchers the least number of times (*n* = 13). Most of the researchers attempted to assess students' affect through a survey. Within the 13 studies, the authors provided the definition using two of the three types in 6 of the studies and using only type in 6 studies (see Table 2.5). In one study, affect was in the title and the study's reference section, but did not appear throughout the text of the article.

2.5.3.1. Operational Definition

The selected studies provided the operational definition three times, with two of them also providing the definition through induction or default. In other words, the authors of two of the selected studies did not provide just the operational definition, but provided other means to describe or define the disposition. The operational definitions included aspects of interest, feelings of positivity or negativity, or eliciting an emotional response. Two of the three operational definitions aligned with the conceptual definition of affect (see Table 2.1), where it assesses a person's feelings toward an object. The definition which focused on interest was not aligned to the conceptual definition.

2.5.3.2. Definition by Induction

More than half of the selected studies provided the definition by induction (see Table 2.5), or used prior research or theoretical underpinnings to define or describe affect. No pattern or theme emerged as far as references or citations to the same prior research or theoretical underpinning, in order words, each of the seven studies relied on different studies to define or describe affect. Two of the studies relied on prior research that measured affect through students' interest and another study relied on prior research that used affective aspects such as attitudes, beliefs, and confidence. Four of the studies relied on prior research that described affect as an emotion or range of feelings that could change rapidly, these four studies were aligned to the conceptual definition of affect.

2.5.3.3. Definition by Default

More than half of the selected studies provided a description of the instrument or provided sample items, thereby providing the definition by default. In three of those studies, only the instrument or sample items were provided, with no operational definition or prior research included to describe the disposition. Additionally, there were no common instruments among the studies administered to assess students' affect. Some of the surveys that were given to assess affect included: *Central Tendency Scale*, the *Scale of Student Engagement in Statistics*, the *Assessment of Interest in Medicine and Science (AIMS)*, *Rutgers Instrument for Mathematics Engagement (RUMESI)*, *BROMP protocol*, and *Pick-a-Mood* tool. Most of the instruments used within these studies actually measured students' interest or attitudes toward STEM. Three of the surveys were aligned to the conceptual definition, the *RUMESI*, *BROMP protocol*, and *Pick-a-Mood* tool all measured students' feelings or emotions during a specific instance.

2.5.3.4. Alignment to the Conceptual Definition

Overall, 6 of the 13 included studies were aligned to the conceptual definition. Additionally, researchers relied on providing the definition by induction or default most frequently when measuring students' affect. The measurement of affect is unique because it is often categorized as a spontaneous reaction, therefore, it may not be of interest to scholars looking to assess the sustainability of an intervention. This could explain why affect was the least represented disposition within the selected studies.

Table 2.5 Affect Alignment by Type of Definition Provided

Definition by	Frequency	Percentage	Examples
Operational Definition	1	7.69%	"Affect, reflecting a student's effort to elicit emotional or physical responses from the audience" (Ward, Price, Davis, & Crowther, 2018, pp. 314–315)
Induction	2	15.39%	"Affect, which is the socio-emotional, non-situational state represented by the collective range of feelings related to learning (McLeod, 1988). In other words, affective engagement is a situational state, bound by time and environment, related to an individual's overall non-situational affect toward a subject." (Lee, Capraro, & Bicer, 2019, p. 271)
Default	3	23.08%	*Pick-A-Mood* tool (Vandevelde, Wyffels, Ciocci, Vanderborght, & Saldien, 2016)
Induction & Default	4	30.77%	
Operational Definition & Induction	1	7.69%	
Operational Definition & Default	1	7.69%	
N/A	1	7.69%	Affect was in the title and reference section but not used within the text of the article

2.5.4. Perception

Perceptions were measured most frequently (n = 146). The majority of these studies (78.08%) provided the definition of perception by default, meaning the authors of the studies did not provide the operational definition or prior research to define perceptions, rather it was defined by the instrument that was administered (see Table 2.6). Additionally, this disposition had the highest number of studies (n = 28) that did not provide enough information to determine the definition of perception or mentioned perception in the abstract, but not anywhere else throughout the paper.

2.5.4.1. Operational Definition

The operational definition was only provided twice among the 146 selected articles. Ntow, Covington Clarkson, Chidthachack, and Crotty (2017) defined perceptions of autonomy based on a students' desire to engage in mathematics because they find it to be interesting and something they can relate to. Farland-Smith and Tiarani (2016) defined perception as "an impression...an awareness based on senses" (p. 183). The second operational definition is in line with the conceptual definition, while the first definition is more about a students' motivation to pursue something.

2.5.4.2. Definition by Induction

Definition by induction was only provided three times among the selected articles. There was no common reference used for defining perceptions, but three out of the four references that were used, focused on the definition of self-efficacy instead of perceptions.

2.5.4.3. Definition by Default

Almost 80% of the selected studies provided the description of the instrument or provided sample items used to measure perceptions. There were over 40 different perception surveys or questions from interviews provided to demonstrate how authors were assessing perceptions. The most frequently administered instruments were the *STEM Semantics survey* (*n* = 9) and *Drawing a Scientist or Engineer* (*n* = 4). These two surveys did measure perceptions toward STEM fields or careers.

2.5.4.4. Alignment to the Conceptual Definition

Overall, in 74 of the 146 (50.68%) selected studies, the author's definition of perception was aligned with the conceptual definition. The authors of these studies relied on definition by default, by providing only the description of the instrument or sample items to indicate how they intended to measure perceptions. Additionally, studies in this disposition conducted more interviews than any other disposition, this was most likely due to the fact that researchers were able to gain more insight into a students' perceptions when they heard their verbal responses rather than completing a written or electronic survey.

Table 2.6 Perception Alignment by Type of Definition Provided

Definition by	Frequency	Percentage	Examples
Operational Definition	-	-	a perception is an impression (Farland-Smith & Tiarani, 2016, p. 183)
Induction	1	0.69%	"possible for students to have the same learning experiences and yet have different perceptions about the nature of their experiences (Ellis et al., 2015)" (Ntow et al., 2017, p. 59)
Default	114	78.08%	Sample items are as follows: Value: "I see how the ideas I am learning during the RET program are valuable to me as a teacher" Utility: "I see how what I am learning here will be useful in teaching my students" Benefits: "I recognize the benefits of skills acquired during RET" Feasibility: "It seems feasible to use the skills and ideas acquired during RET to teach my students" Fit:" What I learned during RET fits well with my own teaching" (Hardré et al., 2018, p. 70)
Induction & Default	1	0.69%	
Operational Definition & Induction	1	0.69%	
Operational Definition & Default	1	0.69%	
N/A	28	19.18%	Perception was in the abstract section but not used within the text of the article

2.5.5. Self-efficacy

The self-efficacy of students and teachers were assessed in 97 of the selected studies. The majority of the studies that measured self-efficacy were conducted in the United States with K-12 students being administered surveys. More than 60% of the studies focused on measuring students' self-efficacy in the context of STEM or Science, rather than the content of these fields. In other words, researchers were more concerned with measuring students' confidence within these subject areas. Within the 97 studies, the authors tended to provide the definition by default, or through induction and default (see Table 2.7). Four of the studies did not provide an operational definition or definition by induction or default.

2.5.5.1. Operational Definition

The selected studies provided an operational definition four times. The researchers in the studies also provided the definition by induction, default, or included all three definitions. These study specific definitions included "defined as the self-appraisal of one's ability to master STEM courses" (Hsieh, 2019, p. 1876), "academic self-efficacy is defined as a belief about student's own personal capabilities" (Gansemer-Topf, Kollasch, & Sun, 2017, p. 203), "see themselves as someone who can "do STEM" in the future" (Vongkulluksn, Matewos, Sinatra, & Marsh, 2018, p. 17), and "an individual's confidence in math-related tasks" (Lee, 2017, p. 5). All four of the operational definitions provided were aligned to the conceptual definition in Table 2.1.

2.5.5.2. Definition by Induction

More than half (*n* = 56) of the selected studies for self-efficacy provided the definition by induction (see Table 2.7) by relying on prior research or theoretical underpinnings to define or describe self-efficacy. Within those 56 articles, self-efficacy was defined through induction (*n* = 39) citing Bandura's definition of self-efficacy. Therefore, Bandura's definition was the most commonly agreed upon definition because it accounted for almost 70%, and his definition is in line with the conceptual definition for self-efficacy.

2.5.5.3. Definition by Default

Definition by default was coded most frequently for self-efficacy, 78.35% (*n* = 76) articles within this disposition included a survey description or provided survey items that were used to assess students' self-efficacy. Over 50 different self-efficacy scales were administered among these studies. The scales (*n* = 21) that were most commonly used included: *Motivated Strategies for Learning Questionnaire (MSLQ)*, *the Science Motivation Questionnaire (SMQ II)*, *Sources of Science Self-Efficacy Scale*, and the *Student Self-Report of Academic Self-Efficacy*. While not all the items on these instruments were aligned with the conceptual definition of self-efficacy, selecting the individual items that assess a person's self-perceptions, or confidence, of their abilities, would be appropriate when measuring self-efficacy. For instance, the item "I am confident in my ability to meet unexpected challenges with success" (Amo, Liao, Frank, Rao, Upadhyaya, 2019) is aligned to the conceptual definition. Some items on the instruments were not aligned to the conceptual definition, like "How much do you enjoy solving problems?" (Schilling & Pinnell, 2019, p. 44). Items that did not focus on a students' confidence should not be included when assessing self-efficacy.

2.5.5.4. Alignment to Conceptual Definition

Overall, in 75 of the 97 (77.32%) selected studies, the authors use of self-efficacy was aligned with the conceptual definition. The authors of these studies relied on definition by induction and default more frequently to define or describe self-efficacy. About one-third of the studies provided the definition by default only, meaning only the instrument description or survey items were provided and neither a definition by induction nor an operational definition were provided to ensure alignment. In two studies, the authors provided all three definitions, which provided the study with more leverage to ensure the disposition was aligned to the conceptual definition.

Table 2.7 Self-efficacy Alignment by Type of Definition Provided

Definition by	Frequency	Percentage	Examples
Operational Definition	-	-	"In this study, academic self-efficacy is defined as a belief about student's own personal capabilities that potentially affect academic and vocational decision making." (Gansemer-Topf, Kollasch, & Sun, 2017, p. 203)
Induction	16	16.50%	"Self-efficacy refers to the confidence in one's ability to successfully complete a task in order (Bandura, 1977, 1997)." (Denson, Kelly, & Clark, 2018, p. 49)
Default	36	37.11%	Example items: Science: I can obtain good grades in science subjects. Technology: I can use the computer properly. Engineering: I am sure that I can build a robot from Lego. Mathematics: I can solve mathematical problems properly. (Halim, Rahman, Wahab, & Mohtar, 2018, p. 13)
Induction & Default	37	38.14%	
Operational Definition & Induction	1	1.03%	
Operational Definition & Default	1	1.03%	
Operational Definition, Induction, & Default	2	2.06%	
N/A	4	4.12%	Insufficient information was provided, there was no description, operational definition, or survey items provided.

2.6. Discussion

The guiding premise for this content analysis was to explore how psychological dispositions (i.e., attitude, affect, perception, self-efficacy) were used and assessed throughout STEM educational research, determine if there was a commonly agreed upon definition or instrument within prior studies, and compare the definitional and measurement alignment to the conceptual definitions of the dispositions. Prior research has suggested there is confusion among researchers when assessing students' attitude, perception, affect, and self-efficacy, because these words are often used interchangeably (Lee & Francis, 2018). The results of the current study demonstrated that there were a number of issues when conducting this meta-analytic, retrospective analysis. For instance, authors may not have considered their work as contributing to a meta-analysis, therefore, they may not have considered providing both operational and interpretational definitions. Those authors who did provide definitions may not have considered alignment between their definitions and a previously validated survey instrument intended to assess that disposition and their use of that instrument. The majority of authors for the selected studies (65%) relied only on the definition by default to assess the disposition. In other words, the disposition was not explored by prior researchers within the literature review nor was an operational definition provided by the authors, only a description of the instrument or survey items were provided. A review of these studies did not unpack the disposition or justify how the administered instrument appropriately measured the disposition. Within each disposition there were a variety of different instruments used to measure the disposition, the *S-STEM survey* was administered to assess three of the four dispositions: attitudes, perceptions, and self-efficacy. This finding alludes to the construct validity of instruments, while not the focus for this specific content analysis, it does lead the current researchers to explore these instruments in more detail to provide construct validity results in future studies.

Out of the four dispositions explored, studies that assessed self-efficacy relied heavily on definition by induction, specifically citing Bandura's work as the theoretical underpinning to define self-efficacy. Additionally, when comparing the other dispositions and alignment to the conceptual definition, the selected studies that measured self-efficacy were better aligned with the conceptual definition. This finding could possibly show the relationship between providing the definition by induction and alignment with the conceptual definition. Another reason could be that there is a clear, well identified person associated with self-efficacy which may have a unifying effect. Conversely, the selected studies measuring attitude were the least aligned to the conceptual definition. This could possibly be due to the varying definitions found in prior research, along with researchers acknowledging the lack of a common definition (see Hillman et al., 2016; Luo et al., 2019; Michael & Alsup, 2016; Thibaut et al., 2018; 2019; Wu et al., 2018). Reaching a common definition for attitude is difficult because hundreds of definitions exist (Albarracin et al., 2005), but it would be fundamental for STEM educational research to support meta-analytic thinking and work toward a more universal definition and therefore, foster a more refined language to unpack the other closely related ideas. Conversely, Fishbein and Ajzen (1977) argue if researchers indicated that attitudes were influenced by other dispositions, it could be argued those dispositions are subsumed within attitudes. This suggestion reiterates the importance of providing operational definitions and definition by induction along with the definition by default to show the justification for how attitude is measured within the context of a study.

2.7. Conclusion and Recommendations

The results from this content analysis yields several conclusions and recommendations for future research. For instance, previous researchers typically do not provide definitions of the disposition they are measuring and use instruments to provide their definition by default. However, this lack of defining the construct has manifested in various definitions and a multitude of surveys intending to measure the disposition. This lack of consensus has caused confusion within the field and may be one cause for a lack of effect on the K-12 education or a perceived lack of usefulness of the research in this area. Therefore, the current authors offer the following recommendations for future researchers. First, future researchers should provide operational definitions, theoretically guided definitions, and a complete list of survey items or measures utilized. This would help to reduce the overreliance on definition by induction or default, which was observed in the present study. It is also important to note due to the lack of uniformity in the definitions, an instrument designed by one researcher to measure a psychological disposition might actually be measuring something very different from what the next author intended when adopting the instrument. The triangulation of these three definitions will provide readers with the needed information to fully understand how the disposition is defined and measured within the context of the study. Second, if an instrument measures multiple dispositions, it would be beneficial to provide subscale results for each individual disposition to provide invaluable insight into the specific dispositions. This will allow for meta-analytic thinking for researchers who may only be interested in a specific disposition. Finally, the results from this study showed a relationship between defining by induction and alignment to the conceptual definition, therefore providing prior research or theoretical underpinnings to define the disposition being measured provided the rationale for the instrument and chosen disposition. Future research on this topic will include exploring the surveys administered to measure these dispositions and to offer insight into the construct validity of the instruments. The results from this current study have the potential to bring consensus among educational researchers by encouraging them to provide a clear definition of the disposition set in the context of their study, provide prior research to describe the disposition, and list sample items which measure the intended psychological disposition.

3. ARTICLE 2: FEMALE STUDENTS' P"HER"CEPTIONS OF STEM DISCIPLINES AND CAREERS

3.1. Introduction

Gender gaps are prevalent within science, technology, engineering, and mathematics (STEM) fields despite the fact these fields are evolving and growing. Careers in STEM fields are expected to grow more quickly than any other field in the world; therefore, students must be prepared and encouraged to pursue the opportunities these fields offer (Tran, 2018). Yet women remain underrepresented in STEM fields and careers in the United States, and this has prompted researchers to determine factors that may discourage female students from pursuing STEM pathways (Ireland et al., 2018; NSF, 2017).

Foundational opportunities in elementary school can have an impact on female students' interest in pursuing STEM fields as they advance into higher and more rigorous STEM content with each grade level (Christensen & Knezek, 2017; Roberts et al., 2018). A weak foundation in STEM disciplines usually corresponds to high school female students being more hesitant to enroll in advanced STEM courses (Brotman & Moore, 2008; Hammack & High, 2014; Heaverlo et al., 2013; Martin & Beese, 2016; Wieselmann et al., 2017). Furthermore, a lack of hands-on and real-world applications in STEM classroom experiences has added to the reluctance female students have toward STEM fields (Christensen & Knezek, 2017; Prieto & Dugar, 2017; Wieselmann et al., 2017). Additionally, female students perceive male peers as inherently possessing qualities that would make them more successful in STEM fields (Wieselmann et al., 2017). Prior research has indicated that female students typically do not pursue STEM fields for these reasons. Therefore, there is a need to determine support structures that may encourage female students to pursue STEM fields, such as considering the ecology of the learning environment.

3.1.1. STEM Project-based Learning

Activities that incorporate STEM PBL promote real-world applications and allow students to see the integration of these often individually taught subjects. STEM should be viewed as one cohesive unit, as it is seen in the workplace by STEM professionals, and its four subgroups should be taught simultaneously with time for hands-on inquiry and project-based activities (Breiner et al., 2012; Capraro & Jones, 2013; Capraro et al., 2018; Gubbins et al., 2013). Specifically, previous research has shown that engagement in STEM PBL activities encouraged high school students to explore STEM content and develop a deeper understanding of the material (Capraro & Jones, 2013). Project-based learning activities also allow students to immerse themselves in the content being taught and develop 21st century skills such as critical thinking, collaboration, communication, and leadership in a positive social learning environment (Bell, 2010; Lee et al., 2019). This learning environment is potentially as important as the skills learned during PBL activities.

Positive learning experiences can translate to positive perceptions of STEM fields (Brown, Collins, & Duguid, 1989, National Research Council, 2009; Roberts et al., 2018). Research has indicated that high school female students were more engaged in tasks that they considered valuable and essential (Watt et al., 2017), and the unique opportunities provided by PBL activities give insight into real-world experiences that are viewed as valuable and essential for academic success and students' communities (Christensen & Knezek, 2017; Roberts et al., 2018). In fact, female students who engaged in STEM PBL activities increased their interest and reached similar levels of intentions to pursue STEM fields as their male counterparts (Christensen & Knezek, 2017). Therefore, the nexus of 21st century skills, the active and engaged learning afforded by STEM PBLs, and the valuable and essential components of the social learning environment create a nurturing and supportive environment for female students.

3.1.2. Student Perceptions of STEM Fields

Perceptions of STEM fields can impact students' interest and motivation in pursuing STEM pathways. Students' perceptions are their interpretations and understandings of prior experiences or their mental impressions of the experience (Wyer & Albarracin, 2005). Perceptions have the power to influence how students feel about a specific experience (i.e., afraid, challenged, interested, supported). However, perceptions can be malleable and are likely to change over time with new experiences (Lee & Francis, 2018). Specifically, motivation, experience, and self-efficacy directly influence students' perceptions (Bandura, 1997; Brown, Concannon, Marx, Donaldson, & Black, 2016; Roberts et al., 2018; Turner & Patrick, 2004). If students are motivated, have had positive experiences with a challenge, or believe they can be successful, they will have a more positive perception about the challenge, therefore it is important for educators to provide these positive experiences or challenges in STEM classes.

The basis of one's perception of STEM is constructed at an early age. Perceptions can be influenced by early childhood role models, such as parents and teachers, and can impact the framing of students' attitudes associated with STEM subjects. Male students typically receive support from parents and teachers around STEM fields, which then promulgates or nurtures confidence and further promotes the idea that they are a good fit for STEM fields (Nosek, Banaji, & Greenwald, 2002). In contrast, female students are often encouraged to focus on sociological fields, where there is a focus on family and children, instead of exploring STEM subjects and being challenged to solve problems like their male counterparts (Dasgupta & Stout, 2014). This early exposure to defined roles influences children's perceptions of their own abilities as they develop into adulthood. Gender roles often predict the differences seen in perceptions of STEM fields between male and female students. Rather than fostering an inclusive environment, stereotypes have categorized most STEM fields as masculine (Cheryan, Ziegler, Montoya, & Jiang, 2017). This enculturing behavior from trusted adults supplant young children's personal preferences. Rather than identifying their own interests and then building their strengths to succeed in that interest, students are trained to gravitate towards a field that corresponds to what trusted adults value and believe.

The masculinization of STEM encourages males to pursue their interest and explore STEM fields; therefore, they are more likely to have positive perceptions even when they are struggling or face adversity. Female students have shown less motivation and confidence in their ability to do well in STEM subjects (London, Rosenthal, Levy, & Lobel, 2011; Vela, Caldwell, Capraro, & Capraro, 2019). Furthermore, female students have adopted the perspective that STEM fields are challenging and assume they do not have the natural talent to succeed (Shin, Levy, & London, 2016). Because females view STEM fields as challenging and underestimate their abilities, they typically have lower perceptions of STEM fields and choose not to pursue the male-dominated STEM fields.

The positive associations between STEM and male capabilities has impacted male students' perceptions of STEM and ensures they are on track as they advance academically. However, this negative stereotype continues to hinder female students' ability to advance in STEM fields at the same pace as their male peers. The greater the extent to which female students ascribed to the male-dominated STEM stereotype, the lower they reported their self-efficacy (Master et al., 2017). Prior research has linked high levels of self-efficacy to students who persist longer, perform better, and are more inclined to pursue a STEM career, while students with low self-efficacy are less likely to pursue a STEM career (Blotnicky, Franz-Odendaal, French, & Joy, 2018; Kwon, Vela, Williams, & Barroso, 2019; Lin, Lee, & Snyder, 2018; Rittmayer & Beier, 2008). This indirect relationship between subscribing to the male-dominated STEM stereotype and lower self-efficacy is a spiral that eventually results in very capable female students not feeling sufficiently prepared for STEM coursework, professions, or post-secondary matriculation.

3.1.3. Interest in Pursuing STEM Careers

Due to the negative perceptions that female students have toward STEM fields, a higher rate of female students than male students choose not to pursue STEM majors and ultimately STEM careers. Even though in high school female students and male students enrolled in advanced science and mathematics courses at equal rates, female students were still less likely to pursue these majors in college (Bofah & Hannula, 2016; Cherney & Campbell, 2011; Demetry et al., 2009; Hill et al., 2010; Lee & Bryk, 1986). Those female students who did decide to pursue STEM majors typically majored in fields such as social sciences, biology, and health services, while their male counterparts were more likely to pursue mathematics and physics majors (Clewell & Burger, 2002; Demetry et al., 2009; Hammack & High, 2014; Han, 2016; Piatek-Jimenez et al., 2018; Watt et al., 2017). Despite the negative stereotypes within STEM fields, research has shown that organizations look for skilled workers who are analytical, logical, and inquisitive, which are gender-neutral skills (Piatek-Jimenez et al., 2018). Because the skills needed for STEM careers appear to be gender neutral and allow for women to be successful in these fields, researchers need to determine factors that will encourage and empower female students to pursue and remain in STEM fields.

3.1.4. Single Gender vs Co-educational Settings Implementing STEM PBL Activities

One factor that has been studied frequently to improve female students' perceptions toward STEM fields is the implementation of single-gender settings. However, research has been inconclusive in determining whether single-gender or co-educational settings are better for female students (Mael et al., 2005). Although there is extensive literature that supports the use of STEM PBLs in co-educational classrooms, there is little research that focuses on STEM PBLs in single-gender settings. Therefore, this study will add to the literature by providing insight into how the implementation of

STEM PBL in single-gender classrooms affect female students' perceptions of STEM fields and STEM careers.

3.2. Purpose of the Study

Because perceptions of STEM begin at an early age, intervening early to capture and maintain female students' interest in STEM fields is necessary to produce more skilled workers for the expanding STEM fields. The purpose of this study was to evaluate middle school and high school female students' perceptions of science, mathematics, engineering, and STEM careers in a single-gender STEM PBL classroom compared to a co-educational STEM PBL classroom. Researchers also examined the correlation between students' science, mathematics, and engineering perceptions and their perceptions of STEM careers. It is important to examine female students' perceptions of STEM disciplines after being engaged in STEM PBL activities in either a single-gender setting or co-educational setting to determine if the setting influences female students to pursue STEM careers. These informal learning experiences have been shown to increase students' interest in STEM fields, their awareness about the variety of STEM fields available, and their desire to pursue a STEM career (Roberts et al., 2018). As stated before, there is currently a lack of literature that expresses how STEM PBL activities affects female students in single-gender classrooms. Data were collected from participants who participated in a residential STEM summer camp. Participants took the *STEM Semantics Survey*, which measures students' perceptions toward mathematics, science, engineering, and their desire to pursue a STEM career.

3.3. Theoretical Framework

This current study uses the expectancy-value theoretical model. Pahlke, Hyde, and Allison (2014) previously implemented this model in their study to examine the gender gap in mathematics and in STEM careers (Pahlke, Hyde, & Allison, 2014). Their study's results indicated that decisions are influenced by two main factors: expectations for success and values (Pahlke et al., 2014). Expectations for success are determined by aptitude, past experiences, acknowledgement and interpretation of the experiences, awareness of own ability, and influence of peers' perceptions (Pahlke et al., 2014). Self-expectations and values will impact decisions for future endeavors (Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005; Watt et al., 2017). In relation to the current study, students may not choose a particular STEM career path if they believe they will not be successful because of past experiences and performance. A single-gender, specifically an all-female, STEM summer camp may provide experiences to increase female students' expectations of success and values. The framework provided through the expectancy-value theoretical model can explain how an all-female STEM camp may impact female students' perceptions of STEM disciplines and future careers compared to co-educational STEM camps.

3.4. Research Questions

1. How does engagement in STEM PBL activities, specifically in single-sex classes compared to co-educational classes, affect student perceptions of science, mathematics, and engineering?

2. How do student perceptions of science, mathematics, and engineering affect their desire to pursue a STEM career?

3.5. Methodology

In order to determine how a one-week STEM summer camp affected female students' perceptions of STEM disciplines, a quasi-experimental study was designed to answer the two research questions. Participants completed the *STEM Semantics Survey* (Knezek & Christensen, 1998, 2008; Tyler-Wood, Knezek, & Christensen, 2010) on their first day and last day of camp to assess their perceptions of STEM disciplines and careers. Data were analyzed by Cohen's *d* effect sizes, paired sample *t*-tests, regression, and a Pearson's correlational analyses.

3.5.1. Participants

There were 138 middle and high school students that participated in either the all-female camp (n=55) or the co-educational camp (n=83; female= 39). Of the 138 participants, 96% were from Texas. The demographics for both camps were as follows: 46% Caucasian, 20% Hispanic, 11% Asian, 9% African American, and 3% mixed. Several students chose not to disclose their ethnicity (11%). For the purpose of this study, only the female students from the co-educational camp and the female students from the all-female camp were included in the data analysis.

3.5.2. Setting

The two summer camps being investigated were designed to engage students in STEM environments. Courses, STEM laboratory tours, informational panels, and night activities were developed to completely immerse the participants in STEM disciplines.

Research has shown student perceptions about STEM careers are promoted when exposed to mentors and role models working in STEM fields (Prieto & Dugar, 2017). The co-educational camp was led by male and female STEM professors and guest speakers to promote STEM disciplines and careers. The all-female camp, specifically led only by female STEM professors and guest speakers, also promoted STEM disciplines and careers, but more specifically highlighted women in STEM.

3.5.3. Instrument

The *STEM Semantics Survey* (Knezek & Christensen, 1998, 2008; Tyler-Wood et al., 2010) was intended to assess participants' perceptions toward STEM disciplines and STEM careers. The original survey included five components (science, technology, engineering, mathematics, and STEM careers) with a total of 25 items. For the purpose of this study, only four components were included, the technology component was omitted, for a total of 20 items. The technology component was excluded from the current study because responses on this component were subsumed within the other four components. Participants were instructed to indicate their impressions of each component by rating the descriptive adjective pairs on a 7-point scale. The same five adjective pairs were listed in random order for each component (i.e., science, mathematics, engineering, and STEM careers). For example, the science component is shown in Figure 3.1. Validity was estimated through similar test correlation: content, construct, and criterion-related procedures (see Tyler-Wood et al., 2010). The reported internal consistency reliability (Cronbach's alpha reliability) for secondary students across all four components was between 0.78 and 0.94 (Tyler-Wood et al., 2010).

To me science is:								
fascinating	1	2	3	4	5	6	7	ordinary
appealing	1	2	3	4	5	6	7	unappealing
exciting	1	2	3	4	5	6	7	unexciting
means nothing	1	2	3	4	5	6	7	means a lot
boring	1	2	3	4	5	6	7	interesting

Figure 3.1 Science Component from the *STEM Semantics* Survey

The *STEM Semantics Survey* (Knezek & Christensen, 1998, 2008; Tyler-Wood et al., 2010) was electronically administered on the first and last day of camp. Three of the five adjective pairs, 1) fascinating… ordinary, 2) appealing...unappealing, and 3) exciting...unexciting, were reverse coded during the analysis. Because of this reverse coding, a higher score on these three pairs was interpreted as the student having a positive perception toward the measured component. Two of the five adjective pairs, 1) means nothing...means a lot and 2) boring...interesting, were already paired to indicate a higher score would represent a positive perception. For the present study, psychometrics were conducted for each of the four components using the collected survey data (see Cronbach, 1951; Nimon, Zientek, & Henson, 2012; Thompson, 2002a). Cronbach's alpha reliability levels for data in hand were between 0.898 and 0.915.

3.5.4. Data Analyses

StataSE 16 was used to analyze the quantitative data. Researchers first calculated effect sizes and conducted paired sample t-tests to determine if there was a statistically significant difference between female students' pre- and post-perceptions of STEM fields based on their camp setting. A priori alpha was set to 0.05 with a Bonferroni correction that changed alpha to 0.0166. Next, researchers conducted a regression analysis on perceptions of STEM careers based on students' perceptions of science, mathematics, and engineering. Using the results from the regression, researchers predicted perceptions of STEM careers. Using this new data, researchers conducted a Pearson's correlational analysis to determine if perceptions in science, mathematics, and engineering could predict perceptions of STEM careers.

3.6. Results

The effects of the STEM camp on female students' perceptions of science, mathematics, and engineering in two different environments, all-female and co-educational, were compared using descriptive statistics, Cohen's *d* effect sizes, and paired sample *t*-tests (See Table 3.1). The means from the pre-test to the post-test increased across all components for the female students in the all-female camp. In contrast, the means from the pre-test to the post-test decreased in perceptions of science, mathematics, and engineering for the female students in the co-educational camp. Perceptions of science were more than a quarter standard deviation higher on the post-test for female students in the all-female camp (d=0.371). In the all-female camp, female students' perceptions of science statistically significantly improved from the pre-test to the post-test (p=0.001). No other results were statistically significant.

Table 3.1 Results for *t*-tests for Each Component

Component	*n*	Pre- M (SD)	Post – M (SD)	Cohen's *d*	*t*-value	*p*-value
All-Female Camp	55					
Science		29.945 (5.592)	31.818 (4.448)	0.371	3.568	0.001**
Math		26.145 (8.066)	27.309 (8.434)	0.141	1.538	0.130
Engineering		27.073 (7.031)	27.836 (7.664)	0.104	0.779	0.439
Females in Co-ed Camp	39					
Science		28.846 (6.663)	28.641 (7.892)	-0.028	-0.294	0.770
Math		26.026 (6.322)	25.615 (8.659)	-0.054	-0.299	0.767
Engineering		28.128 (5.390)	26.846 (7.876)	-0.190	-1.289	0.205

**$p<0.016$

Next, researchers conducted a multiple regression analysis between science, mathematics, and engineering to determine if there was a relationship between these independent variables and female students' perceptions of STEM careers. The multiple regression model with all three predictors produced an *Adjusted* $R^2 = .430$, $F(3, 90) = 24.37$, $p < .001$. Scores for perceptions of a STEM career were then predicted and used for the Pearson's correlation analysis. Students' perceptions in science, mathematics, and engineering were significant positive predictors for STEM career perceptions for the female students in the all-female camp and the female students in the co-educational camp (see Table 3.2). These results indicate there is a strong correlation between positive perceptions of science, mathematics, and engineering and positive perceptions of STEM careers.

Table 3.2 Correlation Between Predicted Career Perception and Components

Components	1	2	3	4
1. *Predicted Career Perception*				
All-Female	-			
Females in Co-ed	-			
2. *Science*				
All-Female	0.809*	-		
Females in Co-ed	0.919*	-		
3. Mathematics				
All-Female	0.781*	0.286	-	
Females in Co-ed	0.559*	0.199	-	
4. Engineering				
All-Female	0.648*	0.332	0.553*	-
Females in Co-ed	0.735*	0.685*	0.251	-

*p<0.01
Note: 1, 2, 3, and 4 represent correlations with the independent variable.

3.7. Discussion

The focus for this study was to examine the impact a one-week STEM summer camp had on female students' perceptions of STEM disciplines and STEM careers. This quasi-experimental study was designed to provide insights into female students in two learning settings, all-female and co-educational, to see if these settings affected female students' perceptions of STEM disciplines and careers. Prior researchers have examined the implementation of single-gender settings to empower female students to pursue STEM disciplines and close the gender gap seen in these ever-growing fields (Mael et al., 2005). The current study expands on prior research by looking at the implementation of STEM PBL activities, but specifically in a single-gender setting compared to a co-educational setting.

Participants in this study (N=138) attended a one-week STEM summer camp that focused on implementing hands-on, real-world projects to see the value in STEM fields as prior research has shown that female students become disengaged and uninterested in STEM disciplines due to lack of hands-on and real-world applications (Christensen & Knezek, 2017; Prieto & Dugar, 2017; Wieselmann et al., 2017). Results from the study indicate that the all-female STEM PBL environment may be more beneficial than a co-educational STEM PBL setting for improving female students' perceptions of STEM, specifically in science ($p<0.01$). This significant improvement could be attributed to the fact that many students associate STEM PBL projects with science and do not view it as an integration of the individual STEM disciplines. Regardless, participants in both settings of the STEM summer camp were engaged in hands-on, real-world applications of STEM concepts. However, only female students in the all-female environment improved their perceptions of STEM fields and careers.

These results corroborate Hammack and High's (2014) results, where they implemented an all-female program and found that female students' perceptions of engineers positively changed after their program. Although female students often feel inadequate when compared to their male counterparts (Wieselmann et al., 2017), the all-female camp allowed female students to excel in STEM PBL activities without fear of being compared to male peers. Additionally, female students often lack encouragement from parents and teachers (Nosek et al., 2002) and perceive STEM fields as masculine (Cheryan et al., 2017). During the all-female camp, participants were encouraged and motivated to pursue STEM fields, and they were exposed to the various STEM areas and heard from female STEM professionals. These experiences allowed female students in the all-female camp to experience a focused view of STEM where women were the leaders and innovators across each of the four disciplines.

The all-female camp had a strong impact on participants' perceptions of linking learning to future careers. There was a strong Pearson's correlation between female students' perceptions of STEM and their perceptions of a STEM career. As perceptions of STEM fields improve so too do students' chances of seeing themselves in a STEM career. When students can see themselves engaged in STEM-focused of jobs, they gain the confidence needed to overcome the obstacles and barriers in front of them to reach such career aspirations. This finding is linked to prior research claims that engagement in hands-on STEM learning activities improve students STEM career interest (Çevik, 2018; Christensen & Knezek, 2017; Sari, Alici, & Sen, 2018). Therefore, one possible road to attracting and retaining women in STEM courses and pathways lies in the linking of perceptions and careers through female STEM professional role models and hands-on STEM learning.

3.8. Conclusion

One possible implication of this study is that formal and informal learning should be linked earlier in secondary education programs. The results from this study suggest that secondary education needs a heavier emphasis on highlighting the integrated pieces of STEM disciplines rather than the individual STEM subjects when engaging students in STEM activities. Formal learning environments typically provide students with active learning experiences in science labs or science experiments. As a result, students tend to associate STEM projects with science and do not see the integration of the STEM subjects. However, in informal settings the emphasis is often on engineering, mathematics, or technology through an integrated learning model; in this study it was STEM PBL.

The STEM PBL learning method specifically places the Engineering Design Process (EDP) as the inquiry model, which frames the focus of projects from an engineering perspective rather than a science perspective. Interestingly, the EDP shares many similarities with the scientific process, which is what is utilized as an inquiry model in most formal classrooms. The similarities between the inquiry models stem from their foundational structure, which teaches students how to share research, develop a prototype, test and refine experiments, analyze data, and communicate results. Unfortunately, the scientific process is often only taught in the context of science courses in science labs and through science experiments. As a result, students sometimes have a hard time unpacking the nuanced differences between STEM learning activities and learning experiences in these settings. If educators can shift students' perspectives to seeing STEM projects from different lenses (i.e., science, mathematics, engineering, and technology) as STEM PBL and the Engineering Design Process encourage them to do, it will allow them to see the aspects of the project in a new light. These new perspectives will allow students to see the creativity and critical thinking needed for real-world STEM projects, which will help guide them down a STEM pathway.

Additionally, there needs to opportunities for female students to see themselves in possible STEM pathways within formal learning settings. This could take place in the form of female STEM speakers or research projects on distinguished female STEM researchers or role models. These types of activities will allow female students to feel empowered and see there is a place for them in these male-dominated fields.

4. ARTICLE 3: TOO FEW WOMEN: FOSTERING ADOLESCENT FEMALE STUDENTS' POSITIVE PERCEPTIONS AND SELF-EFFICACY IN STEM FIELDS

4.1. Introduction

Women are underrepresented in science, technology, engineering, and mathematics (STEM) fields and careers (NSF, 2017). The gender gap, or gender inequality, narrowed during the late 20th century, yet women are still far from seeing gender equity within these fields (Del Carlo & Wagner, 2019; Jayaratne et al., 2003). One study indicated that at least 32% of the female participants experienced some sort of discrimination within the STEM community, evolving from explicit stories of sexism in the past to more implicit instances nowadays (Del Carlo & Wagner, 2019). Therefore, special attention has been placed on encouraging women and girls to pursue STEM fields to a) fill the demand of the STEM workforce, b) bring in diverse ideas and innovations, and c) ensure equity in STEM fields (Ireland et al., 2018; Laughter & Adams, 2012; Margolis & Fisher, 2002; Rosser, 2012). Extensive research has been conducted to identify effective interventions that may help close the gender gap. One intervention that may promote positive female students' perceptions and matriculation into STEM pathways is the use of single-gender learning environments in formal and informal settings. The purpose of this current study is to determine the effects of an all-female STEM summer camp (AFC) on female students' perceptions and self-efficacy toward STEM fields. Through this study, we will determine if engagement in an AFC has a greater impact on those female students who ranked below-average in their perceptions of STEM fields compared to those who ranked average and above-average in their perceptions. The findings from this study may help organizational leaders determine effective interventions to improve female student engagement in STEM fields.

4.1.1. Women's Underrepresentation in STEM Fields

Title IX – Prohibition of Sex Discrimination (1972) was signed into law in 1972 and currently states: "*No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance"* (U.S. Department of Justice, 2015, Sec.1681.Sex[a]). The federal protections afforded by the implementation of Title IX along with a growing emphasis on attracting women to STEM has led to an increase in the number of female students taking advanced mathematics and science courses in high school, but this effect has not manifested in colleges and universities (Clewell & Burger, 2002; Demetry et al., 2009; Hill et al., 2010). The emphasis on female students in STEM fields is critical because despite all of these efforts to attract women to STEM pathways, researchers have found that the increase in the number of female students taking advanced courses as they progress through their formal schooling has not changed the fact that many of them become reluctant to continue this pathway in college (Brotman & Moore, 2008; Hammack & High, 2014; Heaverlo et al., 2013). So, why are female students who possess the needed skills in high school not pursuing STEM majors in colleges or universities (Clewell & Burger, 2002; Hill et al., 2010)? Female students in secondary school are prepared to pursue STEM fields, yet typically choose to pursue other majors.

There are some exceptions to this general pattern. In recent years, there has been an increase in female science and engineering degree holders. Additionally, the NSF (2017) has determined that women are on par with men for completing STEM degrees in specific areas, but they still make up smaller percentages of the STEM workforce. More specifically, the ratio of women is lowest in engineering, computer science, and physics, and highest in psychology, biosciences, and social sciences (Bae, Choy, Geddes, Sable, & Snyder, 2000; Clewell & Burger, 2002; Del Carlo & Wagner, 2019; Demetry et al., 2009; NSF, 2017). The level of participation for women in specific STEM fields has been shown to vary laterally, but the trend in the vertical hierarchy of the STEM fields is that female representation typically decreases as women climb the career ladder (Etzkowitz, Kemelgor, Neuschatz, & Uzzi, 1994). In summary, despite an increase in the number of female students pursuing specific areas within STEM fields, there is still a gender gap in the STEM workforce.

There are a number of underlying social factors that may contribute to the persistence of the gender gap in STEM fields. According to a report by Hill, Corbett, St. Rose, and the American Association of University Women (2010), science and mathematics fields are seen as masculine, while humanities and arts fields are seen as feminine. This may explain why the ratio of women is lowest in specific engineering fields and highest in social science fields. In fact, after graduation women are more likely to be employed in educational institutions as psychologists, technologists, or in health-related occupations, while men are more likely be in the business sector (NSF, 2017). Furthermore, some K–12 educators still view STEM fields as masculine, and these implicit biases may negatively impact female students' attitudes and their perception of being successful in STEM careers (Del Carlo & Wagner, 2019; Martin & Beese, 2016). In one study, female participants in STEM careers mentioned a sense of feeling different from other women and of not following typical feminine stereotypes (Del Carlo & Wagner, 2019). All the participants in this study were passionate about STEM but felt more enjoyment sharing this passion with others than exploring it on their own, which may also explain why women pursue fields with a social aspect (Del Carlo & Wagner, 2019). Because of stereotypical views and the inconsistent representation of women in all STEM fields, it is important to empower female students in a variety of STEM activities and fields to expose them to various STEM career opportunities they may not have considered otherwise.

4.1.2. Affect as the Meta-factor

Affect is influenced by and influences several factors, such as attitude, perception, and self-efficacy. Affect measures people's feelings toward a particular object, which are determined by a persons' emotions and moods toward the object (Berkowitz, 2000; Schimmack & Crites, 2005). In other words, affect determines how a person feels about an object (Clore & Schnall, 2005; Krosnick, Judd, & Wittenbrink, 2005). Affect differs from attitudes because attitudes are determined by an evaluation of a person's degree of like or dislike toward the object (Eagly & Chaiken, 1993; Rosenberg & Hovland, 1960). In contrast, perceptions are interpretations of information about a particular object based on past experiences (Wyer & Albarracin, 2005). Finally, self-efficacy is defined as one's self-perception of their ability to achieve something

(Bandura, 1997; National Academy of Engineering & National Research Council, 2014). Therefore, a person's experiences and self-efficacy will directly affect their perception about a particular object. For instance, if a student perceives themselves capable of being successful in mathematics (self-efficacy), they will have a positive perception of the field of mathematics. This positive perception will allow them to like mathematics (affect) and provide them with information about their attitudes toward mathematics.

4.1.2.1. Self-efficacy in STEM

Similar to the gender gap seen in STEM fields, gender may explain differences in students' self-efficacy, their self-perception of their capability to be successful, in STEM fields. A student's interest and perception of a subject is related to their self-efficacy in that subject (National Academy of Engineering & National Research Council, 2014). According to prior research, male students have higher self-efficacy toward STEM fields than female students (Bandura, 1997; Hyde, Fennema, & Lamon, 1990), and this lower self-efficacy impacts female students' desire to enroll in advanced high school mathematics and science classes (Lent, Lopez, & Bieschke, 1991). In fact, a study found that women who decided to pursue STEM pathways did so because they were "always" interested or because of a specific class or teacher (Del Carlo & Wagner, 2019) indicating that their self-efficacy in STEM was established early on or encouraged by role models, which impacted their perceptions and interest of STEM fields.

4.1.2.2. Perceptions of STEM

Female students typically have a negative perception of STEM fields. Students' perceptions are their interpretations of prior experiences, and these perceptions influence how they feel about those experiences. Perceptions begin to evolve at an early age and are influenced by role models, such as parents and teachers. Often times, parents and teachers inadvertently foster thoughts that men are better suited for STEM fields (Nosek et al., 2002). This early exposure to gendered stereotypes affects students' perceptions of STEM fields as they get older. This could explain why prior research has indicated that secondary male students have more positive perceptions of STEM fields when compared to their female peers (Bae et al., 2000; Jones, Howe, & Rua, 2000; Miller, Slawinski Blessing, & Schwartz, 2006). Additionally, female students were less likely to be encouraged to pursue STEM-related pathways than male students after high school (Mujtaba & Reiss, 2016). When female students do pursue STEM pathways after high school, these experiences often foster more negative perceptions. For instance, one female student decided to teach rather than pursue lab work or research after receiving a STEM degree because a prior experience working in a lab gave her the perception that lab work was isolating and unappealing (Del Carlo & Wagner, 2019). Research has shown that engagement in informal STEM learning environments, such as STEM summer camps or STEM PBL activities, may positively impact female students' perceptions of STEM fields (Roberts et al., 2018; Tran, 2018), and these experiences may prove an effective way to improve female students' attitudes and affect toward STEM fields. Ultimately, improving female students' perceptions of STEM fields may increase their interest in pursuing a STEM pathway.

4.1.3. Informal STEM Environments

Informal STEM settings, that is learning that takes place outside of traditional, formal learning environments, have been shown to positively affect interest in STEM fields (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003; Heaverlo et al., 2013). This is especially important because many schools in the United States spend little time going into depth on major topics and may be more concerned with breadth of topics to ensure students are exposed to all major topics (Schwartz, Sadler, Sonnert, & Tai, 2009). As such, informal STEM learning experiences are potentially the only time that many students can witness science being used within actual, real-world STEM projects, which gives them much-needed context for effective learning and also allows them to be more academically successful outside of school (Barton, 2007; Ladson-Billings & Tate, 1995; Shujaa, 1994). Informal pathways into STEM provide engagement opportunities in a safe, non-threatening, and low-stakes environment that female students may lack in traditional schooling (Brotman & Moore, 2008; King & Pringle, 2019). All-female programs attempt to purposefully create such environments.

All-female informal programs have been conducted in order to examine their impact on female students' self-efficacy and interest in STEM (Hughes, Nzekwe, & Molyneaux, 2013). Hyllegard, Rambo-Hernandez, and Ogle (2017) found that enrichment programs, such as informal STEM environments, geared toward female students may be beneficial in encouraging female students who were not predisposed to pursue STEM pathways to pursue STEM careers at the same rate as their male counterparts. However, students who typically enrolled in these informal STEM environments were most likely already leaning toward a STEM major, which could prejudice results (Demetry et al., 2009). Participation in informal STEM environments may provide additional entry points for female students that they are not afforded during traditional schooling, which could impact their desire to pursue a STEM pathway.

All-female informal programs are intended to foster a better understanding of STEM careers and empower female students to pursue STEM majors without distractions that may be present in co-educational programs. Female students have been found to avoid STEM because of their perceptions of what an engineer is supposed to look like (see Hammack & High, 2014). In one study, after engaging in an all-female mentoring program, the participants experienced a shift in their view of engineers. Their view evolved from a disbelief in their own STEM potential into the belief that they are capable of pursue engineering. Furthermore, prior research argued that informal programs can deflect negative stereotypes and support female students' interest in STEM fields (Hammack & High, 2014; Hyllegard, Rambo-Hernandez, & Ogle, 2017). In contrast to positive findings, other researchers have found that single-gender informal programs have little or no effect on female students. In fact, researchers have reported inconclusive results of informal programs' impact on female students' attitudes toward STEM fields and long-term career choices (i.e., Brotman & Moore, 2008; Jayaratne et al., 2003). The dichotomy of these results indicate there may be other significant factors that may influence female students' attitudes, perceptions, and interest in STEM fields. Therefore, it is important for all researchers to report all significant factors (i.e., curriculum, demographics of staff, social activities, etc.) that may have influenced their results in order to provide a better understanding of what factors influence female students' self-efficacy and perceptions toward STEM fields.

4.2. Theoretical Framework

In this study, Bandura's (1986, 2001, 2012) social cognitive theory was used as a lens to see how students' perceptions and self-efficacy toward STEM fields were associated with and influenced by their informal learning environment. Bandura's social cognitive theory focuses on the relationship between a student's behavior and their learning environment, which aligns with this study because the theory suggests that an individual's perceptions will vary based on their learning environment. The relationship between a student's perception and self-efficacy toward STEM fields and their learning environment may influence their decision to enroll in STEM courses and majors as well as their behavior once they pursue STEM pathways (Bandura, 1986, 2012; Tosto, Asbury, Kovas, Mazzocco, & Petrill, 2016). Informal learning environments, such as a single-gender STEM camp, may provide engagement opportunities that female students miss out on in traditional classrooms, which may have a greater influence on their perceptions and self-efficacy toward STEM fields than traditional classrooms do (Boedecker et al., 2015; Ramey-Gassert, 1996). Furthermore, the single-gender informal STEM environment provides a safe, non-threatening, and low-stakes environment for female students to take initiative of their own learning and expose them to STEM-related careers they may not have considered (Vela et al., 2019; Watkins, Marsick, Wofford, & Ellinger, 2018). Bandura (2001) believes that students are actively engaged in their learning and are not merely spectators. Thus, the informal learning environment of an

AFC STEM camp, which allows female students to feel safe and self-assured enough to actively take on challenging tasks without the fear of failing, is an ideal space for female students to effectively engage in and develop positive perceptions of STEM learning.

4.3. Method

Female students are underrepresented in STEM fields. Prior research has indicated that female students have fewer learning experiences than their male counterparts (Catsambis, 1995). Therefore, in order to increase participation of female students in STEM fields, an AFC was hosted. In order to determine how an AFC affected female students' perceptions and self-efficacy toward STEM disciplines, a quasi-experimental study was designed to answer the following research questions:

1. How do female students' self-efficacies toward STEM fields influence their perceptions of STEM fields?
2. How does engagement in an AFC influence female students' self-efficacies and perceptions of STEM fields?
3. Does an AFC have a greater impact on female students' self-efficacies and perceptions of STEM fields for students with initial below-average, average, or above-average STEM perceptions?

4.3.1. Participants

There were 89 secondary female students (middle school = 46; high school = 43) who participated in the AFC. Most of the participants were from Texas (97%), and the rest were from outside of Texas but inside the United States (3%). Participants were representative of diverse backgrounds: 14% were Asian, 12% were Black or African

American, 21% were Hispanic, 36% were White, 1% were American Indian, 5% identified as other, and 11% chose not to disclose. The camp was an open-enrollment camp; therefore, participant attendance was based on one of the following: 1) self-selected, 2) parents registered them, or 3) were a part of an after-school STEM program that was sponsored to attend the camp. Based on these reasons for attending, it can be assumed that a high percentage of participants had a predisposition toward STEM fields. The response rate for completing both pre- and post-surveys was 70% (n=62), and participant responses were included in the data analysis. The demographics for the sample size were 37 middle school students and 25 high school students. The sample was similar to the entire camp demographics: 15% were Asian, 13% were Black or African American, 19% were Hispanic, 37% were White, 3% identified as other, and 13% chose not to disclose.

4.3.2. Setting

The AFC, conducted at a large university in the southern United States, was designed to engage female students in all aspects of STEM through PBL activities, panels, and laboratory tours. Students' daily schedules included three 90-minute courses, a 45-minute panel, and a 60-minute laboratory tour during the day for one week. The courses were designed with female students' interest in mind (Hyllegard et al., 2017) and included projects such as designing a roller coaster in *Engineering Design*, printing individually designed 3D objects in *3D Printing*, creating their own lip gloss in *Cosmetic Chemistry*, sewing an LED bracelet in *Microcontrollers*, or coding a story using a Boolean Girl Kit. All of these projects were designed to engage female students in rigorous STEM content through authentic projects and encourage them to apply 21st century skills such as collaboration, communication, creativity, and leadership.

For this study, STEM PBL activities were defined as “an ill-defined task within a well-defined outcome situated with a contextually rich task requiring (a group of) students to solve several problems which when considered in their entirety showcase student mastery of several concepts of various STEM subjects” (Capraro & Slough, 2013, p. 2). The 45-minute panel session included female STEM professionals from a variety of STEM fields who shared their experiences and provided insight into the advantages and disadvantages of their career. Prior research has indicated that providing access to mentors and role models in various STEM disciplines can improve student perceptions of STEM fields (Hira & Hynes, 2019; Prieto & Dugar, 2017). Therefore, in addition to inviting female STEM professionals to speak at the panel sessions, the AFC provided participants with an all-female staff, which included members who actively promoted women in STEM. Additionally, participants went on field trips to tour a variety of STEM labs at the research university where the camp was conducted to gain a deeper understanding of various STEM pathways and majors. King and Pringle (2019) assessed female students’ interest in STEM after participation in informal STEM experiences and found that field trips had a large influence on students’ desire to engage in STEM learning. At night, female students participated in various social activities (i.e., board games, swimming, bowling, watching movies, etc.) to bond and strengthen their relationships with other participants and counselors on a more personal level.

4.3.3. Instruments

Students were administered pre- and post-surveys of the *STEM Semantics* (Knezek & Christensen, 1998, 2008) and *Student Attitudes toward STEM* (S-STEM) surveys (Friday Institute for Educational Innovation, 2012). These surveys were projected to measure students' perceptions and self-efficacy toward STEM disciplines, respectively. The *STEM Semantics* survey included a total of 20 items that measured students' perceptions on four constructs: science, engineering, mathematics, and STEM careers. Students were presented with five dichotomous adjective pairs (see Knezek & Christensen, 1998, 2008) for each of the four constructs in a different order for subsequent constructs. Students rated each adjective pair out of seven points, with a maximum of 35 points for each construct. Three of the adjective pairs were reverse coded to represent a higher score as indicative of a more positive perception. The *S-STEM* survey measured students' self-efficacy, or belief in their ability, toward STEM on a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. There was a total of 30 items (see Friday Institute for Educational Innovation, 2012) on the *S-STEM* survey, with 9 measuring science self-efficacy, 10 measuring mathematics self-efficacy, and 11 measuring engineering self-efficacy. Therefore, the maximum score for science self-efficacy was 45 points, mathematics self-efficacy was 50 points, and engineering self-efficacy was 55 points. Cronbach's alpha reliability was calculated for the data present and ranged from 0.84 and 0.95 (see Table 3.1) on each construct, indicating a high reliability.

4.3.4. Data Analyses

First, a path analysis was conducted to determine if there was a relationship between students' mathematics, science, and engineering self-efficacies (*S-STEM* Survey) and their perceptions of STEM fields (*STEM Semantics* Survey) (RQ1). This theoretical model (see Figure 4.1) in the present study was supported by results from previous studies (Brown et al., 2016; Roberts et al., 2018).

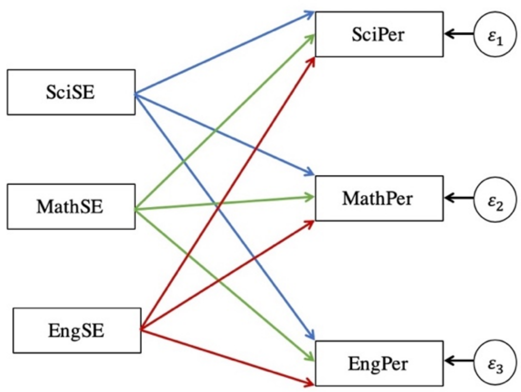


Figure 4.1 STEM Self-efficacy (SE) and Perception (Per) Theoretical Path Model

Next, Cohen's *d* effect sizes, confidence intervals, and *t*-tests were calculated to determine if there were any significant differences between pre- and post-survey results on each construct (RQ2). Researchers have discussed the importance of reporting effect sizes and confidence intervals to indicate practical significance (see Capraro, 2004; Thompson, 2002b; Wilkinson, 1999). Additionally, reporting effect sizes and confidence intervals offer the potential for meta-analytic thinking across studies. In accordance with this line of thought, Cohen's *d* effect sizes were applied to measure mean differences between the pre- and post-surveys (Thompson, 2002b). The following formula (see Equation 1) was used for computing *d* in designs with paired groups (Borenstein, 2009).

Equation 1 Formula for Computing *d* in Designs with Paired Groups

$$d = \left(\frac{\bar{Y}_1 - \bar{Y}_2}{S_{Difference}}\right)\sqrt{2(1-r)}$$

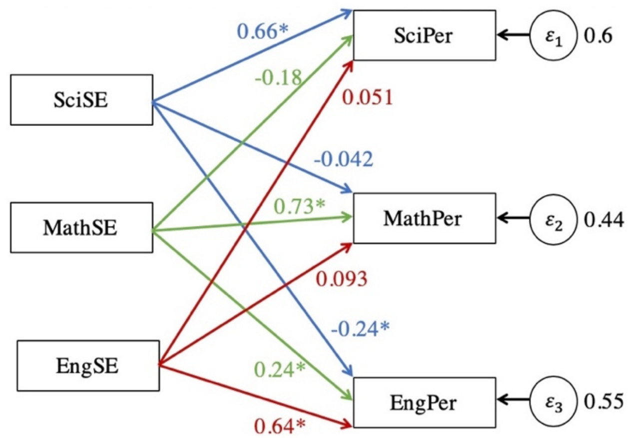
Students' initial perceptions toward STEM fields were calculated using results from the *STEM Semantics* survey by finding the sum of their initial perceptions in the following constructs: science, mathematics, and engineering. A box plot was created to divide the students into three groups (below-average, average, and above-average) based on their initial perceptions of STEM. Any score falling below Quartile 1 (≤74 points) was labeled "below-average perception," any score between Quartile 1 and Quartile 3 (75–98 points) was labeled "average perception," and any score above Quartile 3 (≥99) was labeled "above-average perception." Next, *t*-test analyses were used to determine if there was a statistically significant difference between the pre- and post-surveys among the three groups, and effect size estimates were used to contextualize the observed differences (RQ3). Finally, the 95% confidence interval was calculated to provide an understanding of the accuracy of the estimates and as another indicator of the replicability of the results.

4.4. Results

4.4.1. Influence of Female Students' Self-efficacies on their Perceptions of STEM Fields

To ensure the proposed theoretical model was identifiable, the current researchers used the *t*-rule and null-*b* rule. Both the *t*-rule and null-*B* rule were satisfied, thereby concluding the model was identifiable. Next, the researchers conducted a chi-square test and fit statistics to ensure the model was a good fit. The chi-square test results were $\chi^2(3)= 3.17$, $p = 0.37$, which indicated a good fit. Because the chi-square test is not informative enough to determine if a model is a good fit on its own, researchers also calculated and examined both the standardized root mean square (SRMR) and the room mean squared error of approximation (RMSEA), which were found to be 0.026 and 0.030, respectively. Both of these were less than 0.05, indicating a good fit. Finally, researchers calculated the comparative fit index (CFI), which was found to be above 0.95 at 0.999, indicating a good fit. Modification indices were run, and all modification indices were less than 3.84, which suggested no changes to the model. Therefore, the model was found to be a good fit.

Results for the path analysis (see Figure 4.2) showed a strong relationship between science self-efficacy (SciSE) and science (SciPer) and engineering (EngPer) perceptions, between mathematics self-efficacy (MathSE) and mathematics (MathPer) and engineering (EngPer) perceptions, and between engineering self-efficacy (EngSE) and engineering (EngPer) perceptions. The correlation between these five relationships was statistically significant ($p<0.05$). Additionally, the findings indicate, on average, one standard deviation increase in science self-efficacy would result in a 0.66 standard deviation increase in science perceptions and a 0.24 standard deviation decrease in engineering perceptions. One standard deviation increase in mathematics self-efficacy would result in a 0.73 standard deviation increase in mathematics perceptions and a 0.24 standard deviation increase in engineering perceptions. Finally, one standard deviation increase in engineering self-efficacy would result in a 0.64 standard deviation increase in engineering perceptions.



*p<0.05

Figure 4.2 STEM Self-efficacy (SE) and Perception (Per) Model Results

4.4.2. Engagement in AFC on Female Students' Perceptions and Self-efficacies

To answer research question 2, effect sizes, confidence intervals, and *t*-values were calculated using pre- and post-survey responses for the entire sample on each construct. Students' mean scores in self-efficacy for science, mathematics, and engineering decreased after the AFC; however, these results were not statistically significant (see Table 4.1). The means of perceptions of STEM fields, measured from pre- to post-survey, improved overall for female students after engaging in an AFC (see Table 4.1). The Cohen's *d* effect size for female students' science perceptions was 0.38, and *t*-test results indicated their perceptions statistically significantly increased ($p<0.05$) after attending an AFC. There were no other statistically significant results. To gain a better understanding of the impact of an AFC of female students, researchers divided the participants into initial below-average, average, and above-average STEM perceptions to determine if engagement in an AFC had a greater influence for students in one of these groups.

Table 4.1 Cohen's *d* and *t*-test Results for Pre- to Post-survey Constructs (*n*=62)

Construct (Cronbach's α)	Pre $\bar{x}$ (SD)	Post $\bar{x}$ (SD)	Cohen's *d*	95% CI [min, max]	*t*-value
Self-efficacy					
Science (α=0.95)	37.24 (7.73)	35.73 (8.78)	-0.18	[-0.54, 0.17]	-1.81
Mathematics (α=0.94)	40.56 (8.92)	39.42 (9.33)	-0.13	[-0.48, 0.23]	-1.21
Engineering (α=0.93)	40.71 (9.41)	39.16 (9.87)	-0.16	[-0.51, 0.19]	-1.33
Perceptions					
Science (α=0.84)	30.34 (5.04)	32.11 (4.25)	0.38	[0.03, 0.74]	3.67*
Mathematics (α=0.95)	26.42 (8.31)	27.42 (8.25)	0.12	[-0.23, 0.47]	1.45
Engineering (α=0.94)	27.79 (6.88)	28.29 (7.53)	0.07	[-0.28, 0.42]	0.57

*$p<0.05$

4.4.3. Comparison of Below-average, Average, and Above-average Initial Perceptions

Descriptive statistics for the pre- and post-surveys for each group (below-average, average, and above-average) can be found in Table 4.2. Participants in the below-average group increased their mean scores in science, mathematics, and engineering perceptions and science self-efficacy only. Participants in the average group increased their mean scores in science and engineering perceptions, but means decreased in the remaining constructs. Participants in the above-average group increased their mean scores in science and mathematics perceptions, but their means decreased in the remaining constructs. Despite these changes in the mean scores, only mathematics perceptions for the below-average group and science perceptions for the average group were statistically significant at the $p<0.05$ level, with effect sizes of 0.64 and 0.47, respectively (see Table 4.3). There were no statistically significant changes in STEM perceptions or self-efficacy for the above-average group.

Table 4.2 Descriptive Statistics for Pre- and Post-surveys

	Below Average (n=16)		Average (n=30)		Above Average (n=16)	
Construct	Pre $\bar{x}$ (SD)	Post $\bar{x}$ (SD)	Pre $\bar{x}$ (SD)	Post $\bar{x}$ (SD)	Pre $\bar{x}$ (SD)	Post $\bar{x}$ (SD)
Self-Efficacy						
Science	33.88 (9.55)	34.25 (9.46)	36.07 (6.67)	34.50 (7.91)	42.81 (4.21)	39.50 (9.10)
Mathematics	34.75 (9.23)	34.56 (7.69)	40.40 (8.56)	39.70 (9.04)	46.69 (4.50)	43.75 (9.58)
Engineering	33.69 (8.11)	33.25 (8.84)	40.63 (8.53)	39.37 (8.89)	47.88 (6.82)	44.69 (9.74)
Perceptions						
Science	28.00 (5.43)	30.13 (4.76)	29.47 (4.93)	31.67 (4.40)	34.31 (1.62)	34.94 (0.25)
Mathematics	17.38 (6.78)	21.63 (6.43)	27.27 (6.55)	26.80 (8.64)	33.88 (1.93)	34.38 (1.75)
Engineering	21.13 (5.95)	22.44 (6.75)	27.97 (5.73)	28.57 (7.61)	34.13 (1.89)	33.63 (2.47)

Table 4.3 Cohen's *d* and *t*-test Results for Pre- to Post-survey Perceptions and Self-efficacy toward STEM Fields by Group

	Below Average (n=16)		Average (n=30)		Above Average (n=16)	
Category	Cohen's *d* 95% CI	*t*-value	Cohen's *d* 95% CI	*t*-value	Cohen's *d* 95% CI	*t*-value
Self-Efficacy						
Science	0.04 [-0.65–0.73]	0.36	-0.21 [-0.72–0.29]	-1.23	-0.37 [-1.07–0.14]	-1.74
Mathematics	-0.02 [-0.71–0.67]	-0.15	-0.08 [-0.59–0.43]	-0.50	-0.41 [-1.10–0.33]	-1.26
Engineering	-0.05 [-0.74–0.64]	-0.31	-0.15 [-0.66–0.37]	-0.65	-0.37 [-1.08–0.32]	-1.37
Perceptions						
Science	0.42 [-0.30–1.12]	1.52	0.47 [-0.04–0.98]	3.47*	0.53 [-0.16–1.23]	1.54
Mathematics	0.64 [-0.73–1.34]	2.44*	-0.06 [-0.57–0.45]	-0.52	0.27 [-0.43–0.97]	0.70
Engineering	0.21 [-0.49–0.90]	0.63	0.09 [-0.42–0.59]	0.41	-0.21 [-0.90–0.45]	-1.33

*p<0.05

4.5. Discussion

4.5.1. Research Question 1: How Do Female Students' Self-efficacies Toward STEM Fields Influence Their Perceptions of STEM Fields?

In the current study, researchers examined the relationship between students' initial self-efficacy and perceptions toward STEM fields before attending an AFC. The results of the path coefficients showed that there was a strong relationship between science self-efficacy and science and engineering perceptions, between mathematics self-efficacy and mathematics and engineering perceptions, and between engineering self-efficacy and engineering perceptions. These findings align with prior research that indicates self-efficacy and perceptions are related (Bandura, 1986, 2012; Brown et al., 2016; Roberts et al., 2018). A very interesting result is the fact that engineering perceptions were statistically significantly influenced by science, mathematics, and engineering self-efficacies, indicating that a students' self-perception of their capability to be successful in science, mathematics, and engineering is strongly related to how they perceive the field of engineering. The relationship between a student's mathematics self-efficacy and their perception of engineering was a positive one, indicating that as a student became more confident in their ability to be successful in mathematics, they had a more positive perception of engineering. This could be attributed to the fact that mathematics plays an integral role in many engineering pathways. Consequently, there was an inverse relationship between a students' science self-efficacy and their perception of engineering, indicating that as a students' confidence in their ability of science improved, their perception of engineering would decrease. This inverse relationship could be attributed to the fact that as students become more confident in science and their perceptions of science improve, they become more interested in specific science fields, whereas engineering is applied science.

4.5.2. Research Question 2: How Does Engagement in an AFC Influence Female Students' Self-efficacies and Perceptions of STEM Fields?

Study participants' perceptions in science, mathematics, and engineering increased, but their reported self-efficacy in these fields decreased. This may suggest that the AFC opened students' eyes to the rigor of STEM fields and led them to believe STEM fields require more work than previously believed. Moreover, the *t*-test results for science perceptions showed a statistically significant difference, but the results for students' science self-efficacy did not increase from pre- to post-survey. This suggests that the strong relationship between perceptions and self-efficacy may not always be true as prior research has indicated (see Bandura, 1986, 2012). Students' science self-efficacy may have decreased due to engagement in authentic STEM PBL activities, giving them better insight into the content. Despite their self-efficacy decreasing, their perceptions of the subject may have improved because they engaged in more interesting and real-world STEM PBL activities. In addition, it may be harder for students to develop a stronger self-efficacy in a short time period, whereas positive perceptions of the content may not need as long to develop. Perhaps if the intervention was longer, greater positive improvements in both students' perceptions and self-efficacy toward these fields could be expected. Overall, means in students' perceptions toward science, mathematics, and engineering did increase after attending an AFC. This may suggest that AFCs can help female students become more engaged in STEM fields and have better perceptions toward STEM topics, which may encourage them to pursue STEM majors in college.

4.5.3. Research Question 3: Does an AFC have a Greater Impact on Female Students' Self-efficacies and Perceptions of STEM Fields for Students with Initial Below-average, Average, or Above-average STEM Perceptions?

In order to determine if engagement in an AFC had a greater impact on female students with initial below-average, average, or above-average STEM perceptions, data were analyzed between these three groups. Researchers noted increases in the means for the below-average group in four of the six constructs and only two constructs for the average and above-average groups. This may indicate that engagement in an AFC may have a greater impact on those students with initial below-average perceptions toward STEM fields. Students' self-efficacy did not statistically significantly change in any of the groups; this could be because self-efficacy refers to how a person perceives their ability to achieve something (Bandura, 1997). The AFC may not have impacted female students' self-efficacies because they could have been unsuccessful in some of the projects they engaged in during the camp; ultimately, attending the camp did not increase their self-efficacy. However, student perceptions of STEM fields improved despite the decrease in the means of their self-efficacies, which contradicts prior research that notes a direct relationship between self-efficacy and perceptions (see Brown et al., 2016; Roberts et al., 2018). Based on prior research, perceptions are more malleable and likely to change over time with new experiences (Lee & Francis, 2018); the new experience of an AFC and being exposed to the various pathways of STEM improved the female students' perceptions of STEM. Specifically, the below-average group had a statistically significant impact in their mathematics perceptions, and the average group had a statistically significant impact on their science perceptions. Our results confirm prior research, which indicated that female students with low self-esteem, interest, or self-efficacy were impacted the most when they engaged in informal STEM programs that were designed to increase interest in STEM pathways (Hernandez et al., 2014; Hulleman, Godes, Hendricks, & Harackiewicz, 2010; Hulleman and Harackiewicz, 2009; Hyllegard et al., 2017). Students with above-average perceptions most likely did not show statistically significant changes because of the ceiling effect; there is not much room for improvement for this group of students. This may suggest that engaging in informal STEM programs geared toward encouraging female students will have a greater impact for students with a lower predisposition to STEM fields than for students with above-average perceptions. However, Del Carlo and Wagner (2019) imply that even though the above-average group may have always been interested in science, it does not diminish the importance of engaging in informal learning environments. In fact, it may reinforce their interest.

4.6. Conclusion and Scientific Scholarly Significance

Delving deeper in order to understand the female students who participated in an AFC allowed us to discover some important aspects of self-efficacy and perceptions that that will help inform recommendations for educators of female students who have below-average or average initial perceptions of STEM subjects. Teachers need to be aware of how perceptions and self-efficacy work together in female students so that they can facilitate this interconnected relationship by improving female students' self-perceptions of their abilities and ultimately help them be successful in science, mathematics, and engineering. Additionally, teachers must bolster female students' perceptions of STEM fields by providing them with female role models, engaging them in STEM PBL activities, and taking them on STEM-related field trips to see STEM in action. Although the path analysis conducted in this study indicated a relationship between initial self-efficacy and perceptions, post-results indicated a significant increase in students' perceptions of mathematics and science but no significant changes in self-efficacy. This suggests there may be other factors that influence perceptions of STEM fields. Informal learning environments, such as participating in an AFC, might be such a factor, and may cultivate positive STEM perceptions that can encourage students to pursue STEM pathways and ultimately lead to a more STEM-literate society. Furthermore, this study adds to the body of literature by grouping students into below-average, average, and above-average initial perceptions to determine if engagement in an informal learning environment, such as an all-female STEM summer camp, has a greater influence on one of these groups. Results indicated the AFC influenced female students in the below-average and average groups the most. Thus, it is important for teachers to encourage and motivate discouraged female students. Schools and informal STEM activities can provide opportunities to solidify and improve female students' positive STEM perceptions through summer camps, museums, zoos, laboratories, and additional activities that include the participation of female role models, all of which allow for positive exposure to STEM learning.

5. CONCLUSIONS

The expanding STEM pipeline is compounded by the prevalent gender gap (NSF, 2017). Therefore, researchers have been looking for methods or programs that will encourage more female students to pursue STEM fields. Given the expanding opportunities this is the right time to fill that need with more capable female STEM professionals. Prior research has indicated that participation in informal learning programs, such as summer camps can have a positive influence on students' perceptions and interests toward STEM (Capraro & Jones, 2013; Christensen & Knezek, 2017; Clewell & Burger, 2002; Darke et al., 2002; Jayaratne et al., 2003; Roberts et al., 2018; Tran, 2018). Specifically, informal learning programs geared toward female students help deflect negative stereotypes of STEM fields (Hammack & High, 2014; Hyllegard et al., 2017). Previous research has shown a positive correlation between positive perceptions and self-efficacy in STEM with motivations to pursue STEM fields in the future (Blotnicky et al., 2018; Del Carlos & Wagner, 2019; Kwon et al., 2019, Vela, Pedersen, & Baucum, 2020). My focus was and remains, on empowering female students to pursue STEM fields through an all-female STEM summer camp.

The overall findings from this dissertation show that engagement in an all-female STEM summer camp was conducive for empowering female STEM students. They claimed to have greater interest and were more likely to persist in a STEM field. They demonstrated increased perceptions and self-efficacy related to their experiences and toward STEM fields, in general. Results from study 1 provided the foundation for how to analyze students' perceptions and self-efficacy toward STEM fields. My results from study 2 indicated that females in the all-female camp improved their science perceptions when compared to the female students in the co-educational comparison group. These results aligned with prior research, which revealed that all-female camps allowed female students to explore STEM topics, be successful in STEM activities, and see women as leaders in various STEM pathways, without the influence of their male counterparts (Hammack & High, 2014). Additionally, as the female students' perceptions toward STEM fields improved their perceptions of a STEM career also improved. This could mean as they began to have more positive perceptions of STEM they could also see themselves in a STEM career. It could also mean the positive and or perceived empowerment had a translational effect that carried over to their career interests. Regardless, the effect was both positive for their interests and careers while empowering them to be successful.

Expanding on study 2, the analysis in study 3 considered only the female students who attended the all-female camp. This was to determine if participation in an all-female camp had a greater impact on those female students who ranked themselves with below-average, average, or above-average perceptions of STEM fields. First, we found there was a positive correlation between students' self-efficacy and perceptions, indicating that as students become more confident in their abilities, their perceptions of that discipline also increased. However, our results did not support the inverse relationship, *t*-test results showed science perceptions statistically significantly improved, but participants' science self-efficacy did not significantly change after attending the all-female summer camp. This could be due to the fact that it could be harder for students to develop a stronger self-efficacy in a short period of time, while perceptions toward a STEM field may not need as long of an intervention to be impacted.

In order to understand these results more, we divided the female students into three groups: below-average, average, and above-average STEM perceptions to determine if attending camp had a greater impact on one of these groups. Results showed science perceptions for the average groups significantly improved and mathematics perceptions for the below-average significantly improved. This highlights the notion that informal summer camps may have a greater impact for those students who do not have an above-average predisposition toward STEM fields. These results supported a prior study that found informal programs geared toward female students, who were not predisposed to pursue STEM fields, were beneficial in improving their interest and ultimately encouraged them to pursue STEM pathways (Hyllegard et al., 2017). However, these results do not diminish the fact that participating in informal learning environments may reinforce interest for those students who already have an above-average perception of STEM fields.

The findings in this dissertation are important primarily for five reasons. First, it provided insight into how psychological dispositions have been measured, used, and defined throughout STEM education research. The results provided recommendations for future researchers to include conceptual definitions, and definitions by induction and default to contextualize the use of the psychological disposition within their study.

Second, it provides insight into female students' perceptions and self-efficacy toward STEM fields. This information will be useful for organizational leaders to determine methods or strategies to improve these dispositions to motivate female students to pursue and remain in STEM pathways. Third, it highlights the need to link the individual STEM subjects together in integrative projects, similar to those implemented during the summer camps. If formal schooling could begin to incorporate methods of informal learning – such as PBLs, which incorporate the integrated pieces of STEM disciplines in real-world scenarios. Completing these types of integrated projects, allows students to see the relationships between the individual disciplines and how they all work together in the real-world. Additionally, allowing students to see the creativity and critical thinking needed in STEM careers. This revelation may guide students to pursue STEM pathways. Incorporating STEM panels in formal school settings, which include female STEM professionals, will show that females are represented in STEM fields and allow female students to see themselves in these same fields. Fourth, my results call on teachers to encourage and motivate students with lower predispositions toward STEM fields to participate in informal learning environments, such as summer camps, to provide them with positive experiences in real-world STEM projects, seeing female STEM professionals in these fields, and visiting various STEM labs to make them aware of the many opportunities in STEM pathways. Finally, the findings from the corpus of this dissertation provides a roadmap for navigating the STEM landscape and for developing new research lines that examine methods and strategies to increase the number of female students pursuing STEM fields and majors, in order to close the gender gap in STEM fields and promote a diverse STEM workforce.

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