3-20-2020

Examining the Effects of Familial Occupations and Early STEM Experiences on Female Students' STEM Identity and Career Intentions

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EXAMINING THE EFFECTS OF FAMILIAL OCCUPATIONS AND EARLY STEM EXPERIENCES ON FEMALE STUDENTS' STEM IDENTITY AND CAREER INTENTIONS

A dissertation submitted in partial fulfillment of

the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

CURRICULUM AND INSTRUCTION

by

Susie M. Cohen

2020

To: Dean Michael R. Heithaus
College of Arts, Sciences and Education

This dissertation, written by Susie M. Cohen, and entitled Examining the Effects of Familial Occupations and Early STEM Experiences on Female Students' STEM Identity and Career Intentions, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

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Date of Defense: March 20, 2020

The dissertation of Susie M. Cohen is approved.

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Vice President for Research and Economic Development
and Dean of the University Graduate School

Florida International University, 2020

DEDICATION

This dissertation is dedicated to:

My parents, Joseph and Alice Murugan, who have always believed in me. They devoted their lives to ensure that I was always surrounded by love, support and prayers.

My loving family, my husband Steve and daughters Christy and Kaitlyn. Their enthusiastic support made this dream a reality.

My heavenly father, who consistently sustains me.

ACKNOWLEDGMENTS

Most importantly, I would like to acknowledge my committee members. The first of these is my advisor, Zahra Hazari. Over the years, I found her to be an outstanding role model and mentor who demonstrated concern for my personal and academic development. She facilitated avenues to enable me to develop as a scholar and researcher. My life is richer having known her as a mentor and friend. Along these lines, my other committee members, Emily Dare, Haiying Long, and Geoff Potvin, also provided valuable support and mentorship. They instilled in me a love for research and surrounded me with consistent encouragement.

I am also thankful for the STEM Transformation Institute and for the supportive faculty, graduate students, and post-docs. Through my interactions with these individuals, I have grown as a scholar and developed many friendships. I acknowledge the financial support from FIU University Graduate School through a Dissertation Year Fellowship, as well as the State of Florida through the 2018-2019 State University System of Florida Legislative Budget Request. These organizations have made valuable investments in the field of STEM education and have enabled me to complete my dream of earning a doctoral degree. I also appreciate my interactions with individuals within the School of Education, the College of Arts, Science and Education, and Academic Planning and Accountability and recognize the valuable graduate assistantships that were provided during my doctoral work.

On a more personal note, many thanks to my immediate and extended family and friends. The support and love from my parents, Joe and Alice, and parents-in-laws, Gary and Marion were invaluable. They ran errands, made meals, took care of children, and prayed. They made this journey a much easier one. Special appreciation to my husband and best friend, Steven. He encouraged me to pursue my life-long dream and supported me through it. I could not have asked for a more loving and understanding partner in life.

ABSTRACT OF THE DISSERTATION

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by

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Professor Zahra Hazari, Major Professor

The studies within this collected papers dissertation investigate the effects of familial occupations and early experiences in STEM on female students' STEM identity and career intentions. The saliency of this topic originates from the underrepresentation of women in STEM-related occupations within the United States, and the urgent need to develop a diverse STEM workforce that can excel in a global environment. Familial occupations in STEM and early experiences both play dominant roles in the identity development of female students and how they navigate through later STEM experiences and inevitably select careers.

The three papers were guided by a variety of theoretical frameworks including STEM capital, STEM identity, and STEM identity capital. These frameworks provide lenses to examine familial occupations and early STEM experiences as contributors of STEM capital which serve to impact and continually reinforce STEM identity. The first paper specifically focuses on familial occupation in STEM and the relationship to STEM career intentions. Regression models were created to test the effects of having individual and multiple family members employed in STEM related careers. The second paper explores the effects of familial occupations and early STEM experiences on STEM identity and identity capital. Using blocked regression, specific familial occupations and early experiences in STEM were identified as predictive of STEM identity and translated into STEM identity capital. The third paper examines qualitative data to understand the lived early STEM experiences of female students as related to critical factors identified in earlier papers. These phenomenological case studies present findings connected to identified themes that emerged from analysis to help explain how and why certain factors affect STEM identity.

Results from these studies indicate that having familial occupations in STEM and being exposed to specific early STEM experiences are important for students' STEM identity development and maintenance. These results have important implications for school administrators and educators related to the types of STEM programs/activities and professional training opportunities that may be the most valuable for fostering students' STEM identity.

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CHAPTER 1
INTRODUCTION

Within the United States, career intentions in science, technology, engineering and mathematics (STEM) fields have been widely discussed over the past few decades. Many of these conversations have been fueled by researchers and policymakers who recognize the urgent need to develop a future workforce capable of excelling in a global environment of increasing technological advancements and scientific innovations (National Science Board, 2016). For individuals who do pursue and persist in the STEM fields, men outnumber women and the underrepresentation of women has become a growing concern. According to the U.S. Department of Commerce (2017), “While nearly as many women hold undergraduate degrees as men overall, they make up only about 30 percent of all STEM degree holders. Women make up a disproportionately low share of degree holders in all STEM fields, particularly engineering” (p. 1). In examining factors that contribute to the underrepresentation of women in STEM fields, studies have identified issues such as lack of interest (Blickenstaff, 2005; Ceci & Williams, 2010), inadequate high school preparation (Huang & Brainard, 2001; Margolis, Fisher, & Miller, 2000; Seymour & Hewitt,1997), absence of female role models (Blickenstaff, 2005; Herrmann et al., 2016), and stereotype threats (Schuster & Martiny, 2017; Steele, 1997).

Researchers are perpetually exploring and consistently observing significant influences that might promote the persistence of women in STEM fields. One identified constant and strong predictor of career intentions is identity (Bieri Buschor, Berweger, Keck Frei, & Kapper, 2014; Hazari, Sonnert, Sadler, & Shanahan, 2010; Kane, 2012). Identity research indicates that developing a strong identity in STEM promotes the selection of advanced STEM classes in high school (Updegraff, Eccles, Barber, & Obrien, 1996; Watt, 2006), influencing the subsequent selection of a college major (Watt, 2006). Therefore, it has become salient to determine factors that assist with the development and growth of a robust identity in STEM, especially during early stages of life when identities are forming, and students are most impressionable.

One factor reported as influencing identity is familial occupations in STEM. Some prior studies have been conducted in relation to the employment of family members (Korupp, Sanders, & Ganzeboom, 2002; Sikora & Popropek, 2012; Stevens & Boyd, 1980); however, many of these works lack relevance to the current STEM job market which has changed substantially over the past decade. Another promising factor related to identity is early STEM experiences and these experiences have been explored to some extent in the literature (Pantoya, Aguirre-Munoz, & Hunt, 2015; Yoon, Dyehouse, Lucietto, Diefes-Dux, & Capobianco, 2014). However, most studies related to STEM experiences and identity, focus on middle and high school students (Hughes, Nzekwe, & Molyneaux, 2013; Kim, Sinatra, & Seyranian, 2018; Lock & Hazari, 2016).

Considering observed connections of familial occupations and early STEM experiences on STEM identity, further exploration of these factors is salient. The studies within the dissertation add to the literature by providing current and comprehensive analyses on the relationship between these two factors and STEM identity and career intentions. Furthermore, the factors *familial STEM occupations* and *early STEM experiences* are viewed from a nuanced theoretical perspective where they are regarded as sources of STEM capital and contributors to STEM identity capital and career intentions. These frameworks will be discussed in more detail in the theoretical framework section following the literature review.

1.1. Review of the Literature

This section provides an overview of the literature related to the studies on familial occupation and early STEM experiences.

1.1.1. Career Intentions

Within the surveys utilized in this dissertation, students' career intentions were identified based on their responses regarding what best described what they wanted to be during their first year of college. The STEM occupations that I selected for analysis were broadly based on recommendations provided by the United States Census Bureau and the United States Department of Commerce. It is inclusive of core occupations of sciences, engineering and mathematics, as well as "… professional and technical support occupations in the fields of computer science and mathematics, engineering, and life and physical sciences" (U.S. Department of Commerce, 2017, p. 3). The current definition is also inclusive of medical and health professions, social science, and STEM education.

Career intentions of young people refer to their aim or plan to pursue a specific career (Sadler, Sonnert, Hazari, & Tai, 2012). During childhood, students begin to acquire general awareness of careers and what it means to be employed (Watson & McMahon, 2005). As they grow and learn, students' understanding of occupations becomes extensive. In a study conducted by Robinson and Diale (2017), students in grade 7 begin having discussions related to how family members influence career intentions and fulfillment of dreams. In high school, Medvide and Blustein (2010) document student dialogues on career planning and school engagement. Early STEM experiences are critical, and a large body of literature supports the claim that early STEM involvement can heighten interest and performance in young children, leading to STEM career intentions (Pantoya et al., 2015; Yoon et al., 2014).

With regards to gender, studies reveal that women pursue less prestigious jobs even though they are equally qualified as men (Freeman, 2004). In other cases, women do not select these occupations, but pursue other lower level jobs because they are noncompetitive (Niederle & Vesterlund, 2007) and allow flexible working hours (Eccles, 2007; Tremblay, 2002). Selecting jobs in STEM-related fields is especially problematic for women since many of these occupations are inflexible with specific time constraints (Frome, Alfeld, Eccles, & Barber, 2006). In other cases, women are discouraged by stereotype threats (Cundiff, Vescio, Loken, & Lo, 2013; Schuster & Martiny, 2017), lack of interest in STEM (Ceci & Williams, 2010), and lack of confidence in their ability to persist (Dweck, 2006). Numerous studies conclude that males have a greater intent to pursue STEM careers than females (Christensen & Knezek, 2017; Holmes, Gore, Smith, & Lloyd, 2018; Lauermann, Tsai, & Eccles, 2017; Sadler et al., 2012). In relation to STEM interest, males are more likely to express interest in STEM than females (Sadler et al., 2012; Su, Rounds, & Armstrong, 2009). Lack of support from teachers (Hanson, 2009) and fear of underperformance (Correll, 2001) further discourages development of STEM interest amongst females.

Mau and Bikos (2000) created a model for educational and vocational aspirations to explain the development of career intentions, particularly for marginalized groups in STEM, which includes female high school students. The model included four clusters of variables: psychological, family, school, sex and race. Mau and Li (2017) used portions of the Mau and Bikos model to test for factors that influence STEM career aspirations among underrepresented high schoolers and found that socio-economic status, gender, race, mathematics interest, and science self-efficacy predicted STEM career aspirations. Other theoretical frameworks have been utilized to analyze students' STEM intentions. Some of these are expectancy-value theory (Lauermann et al., 2017; Sáinz & Müller, 2018), social cognitive career theory (Carpi, Ronan, Falconer, & Lents, 2017; Kang & Keinonen, 2017), and identity lenses (Godwin, Potvin, Hazari, & Lock, 2016; Hazari et al., 2010).

1.1.2. Familial STEM Occupations

Within the surveys utilized for the collected papers dissertation, students were asked to report their family members' employment in STEM-related fields. In the first survey (Sustainability and Gender in Engineering) reported in Chapter 2, students were asked to select if they had family members employed as medical/health professionals, scientists, engineers, or other science, technology, or math related careers. In the second survey (How Pre-College Informal Activities Influence Female Participation in STEM Careers) utilized in Chapter 3, students were asked if they had family members involved in a STEM career. They were informed that STEM stands for Science, Technology, Engineering, Mathematics. Family members included in both surveys were male parent/guardian, female parent/guardian, siblings, and/or other relatives. Herein I provide a condensed review of the literature related to familial occupations in STEM, additional reviews are provided in all three papers (Chapters 2, 3 and 4).

From directly teaching their children to functioning as role models, parents shape the thoughts and influence the decisions of their children (Eccles, 1993; Parsons, Adler, & Kaczala, 1982). Parental influences can have significant effects on their children's lives including their academic achievement (Benner, Boyle, & Sadler, 2016), career intentions (Jodl, Michael, Malanchuk, Eccles, & Sameroff, 2001; Otto, 2000), and persistence in specific fields (Kumar, 2016). An area in which parents can implicitly influence their children is through their own occupations. In a study completed by Sikora and Pokropek (2012) using data from 24 countries, they determined that parental occupation and students' intent to work in science careers have a significant relationship. Likewise, using freshman college surveys within the United States, Jacobs, Ahmad and Sax (2017) found similar results related to engineering. Intergenerational transmission studies also report significant positive relationships between fathers' careers and sons' interests in similar careers (Korupp et al., 2002; Sikora & Pokropek, 2012), and daughters being influenced by their mothers' occupations (Jacobs et al., 2017).

Although the literature is sparse when it comes to siblings' and other relatives' occupational influences, the presence of relational support and encouragement from these sources can assist with career intentions. Siblings develop a hierarchical relationship where older siblings offer advice and encouragement to younger siblings (Martinez & Castellanos, 2018; Tucker, Barber & Eccles, 1997). They also provide each other with informational support on careers and social integration (Schultheiss, Palma, Pedragovich & Glasscock, 2002). Other relatives offer emotional (Dunifon & Kowaleski-Jones, 2007) and affective support (Bengtson, 2001).

1.1.3. Early STEM Experiences

Within the surveys that were utilized for papers two and three of this dissertation, students were asked to respond to items related to their participation in specific K-4 STEM experiences. In addition to rating their K-4 science experiences, they were also prompted to identify individuals who provided early encouragement.

Young children can participate in STEM experiences in multiple and varied environments. These early opportunities might present themselves in formal situations, such as in school where students interact with teachers/peers and/or read textbooks, or informal settings such as an after-school STEM club, where they construct circuit boards or build model rockets in a relaxed environment. Students that participate in these early STEM experiences benefit greatly. These experiences can help shape their STEM identity (Pantoya et al., 2015; Yoon et al., 2014), improve their academic performance (Aru & Kale, 2019; Nyberg, 2014; Sackes, Trundle, Bell, & O'Connel, 2011), and increase their STEM interest (Maltese, Melki, & Wiebke, 2014; Maltese & Tai, 2010).

Early STEM experiences have been reported to be different for boys and girls. In a study by Cvencek, Meltzoff, and Greenwald (2011), elementary school-aged girls showed less of an identification with mathematics than boys. In adolescent years, Jones, Howe, and Rua, (2000) indicated that boys were more involved in extracurricular activities that included tools such as pulleys and batteries than girls, while girls had greater participation in activities such as bread-making and planting seeds than boys. Additionally, boys were more inclined to see the learning of science and technology as a necessity (Mehmet, 2012).

Receiving parental and elementary school teacher encouragement in STEM during early years is critical for children. In looking specifically at parents, children who have encouraging and supportive parents have solid academic performance (Brough & Irvin, 2001; Gonzalez, Doan Holbein, & Quilter, 2002), few behavior problems (Sheldon & Epstein, 2002), and increased motivation and interest (Chakraverty & Tai, 2013; Gonzalez-DeHass, Willems, & Holbein, 2005). Parents can encourage and motivate their children in a variety of ways. One way is through providing extrinsic rewards such as privileges or verbal praise, another is by encouraging their children to see value in a particular activity while sparking interest and triggering internal motivation. Parental encouragement in STEM might range from providing academic reinforcement at home (Civil, Díez-Palomar, Menéndez, & Acosta-Iriqui, 2008; Valle & Callanan, 2006) to exhibiting a positive attitude toward STEM (Perera, 2014). Parents might also motivate girls through challenging stereotypes and providing positive female role models (Hill, Corbett, & St. Rose, 2010).

Teachers are also identified as being critical contributors to the career decision making process for students (Hall, Dickerson, Batts, Kauffmann & Bosse, 2011). Within an elementary classroom, they encourage early interest and learning in STEM though their instructional practices (Flannagan & McMillan, 2009; Schweinle, Meyer, & Turner, 2006) and beliefs (Lumpe, Czerniak, Haney, & Beltyukova, 2012; Polly et al., 2013). In later years, Alcott (2017) reported that teacher encouragement influences educational progress, and it is especially salient to students who might not attend college. Kelly and Zhang (2016) also observed a relationship between supportive teacher relationships and student engagement in mathematics and science. Teachers can encourage students in

STEM through communicating that students' ideas are valuable, treating them equally and with respect, and finding avenues to increase their enthusiasm and interest (Kelly & Zhang, 2016).

1.2. Theoretical Framework

1.2.1. Capital and STEM Capital

Being very interested in power and social dynamics and the transference across and within generations, Pierre Bourdieu, a French social theorist, is recognized for his framework on social reproduction (the way systems are governed and reinforced) inclusive of habitus, field, and capital (Grenfell & James, 1998). *Figure 1* broadly depicts the framework focusing on capital, which provides a guiding lens for the present research. *Habitus* is referred to as internal dispositions that a person develops as a result of life experiences that have the potential to directly influence thoughts and actions. "Habitus, as shaped by individual and collective histories, provides a framework of dispositions that guide (and set the limits of) future actions" (Archer et al., 2012, p. 5). *Field* is the structured social systems in which an individual exists and operates. These systems may overlap, but each one exists under its own rules and laws (Grenfell & James, 1998). Within the fields, individuals compete for valued social positions. *Capital* exists in various forms and is associated with assets that have been accumulated. According to Bourdieu (1986), there are four types of capital: social, economic, symbolic, and cultural. Social capital is connected to contacts that an individual might have "… which, through the accumulation of exchanges, obligations and shared identities, provide actual or potential support and access to valued resources" (Bourdieu, 1993, p.143). Economic capital refers to, "…goods that individuals have such as property, wealth, and other financial objects" (Yüksek, 2018, p. 1092), while symbolic capital is defined by knowledge and recognition a person receives, such as degrees and promotion (Bourdieu, 1986). Cultural capital is the accumulation of various resources over time such as, skills, tastes, and credentials, that allow an individual to possess societal benefits (Kisida, Greene, & Bowen, 2014). According to Bourdieu (1986), cultural capital exists in three states: Embodied (the form of knowledge that resides within us), Objectified (material objects we use to indicate social class), and Institutionalized (the way society measures social capital, e.g., educational credentials such as acquiring a degree).

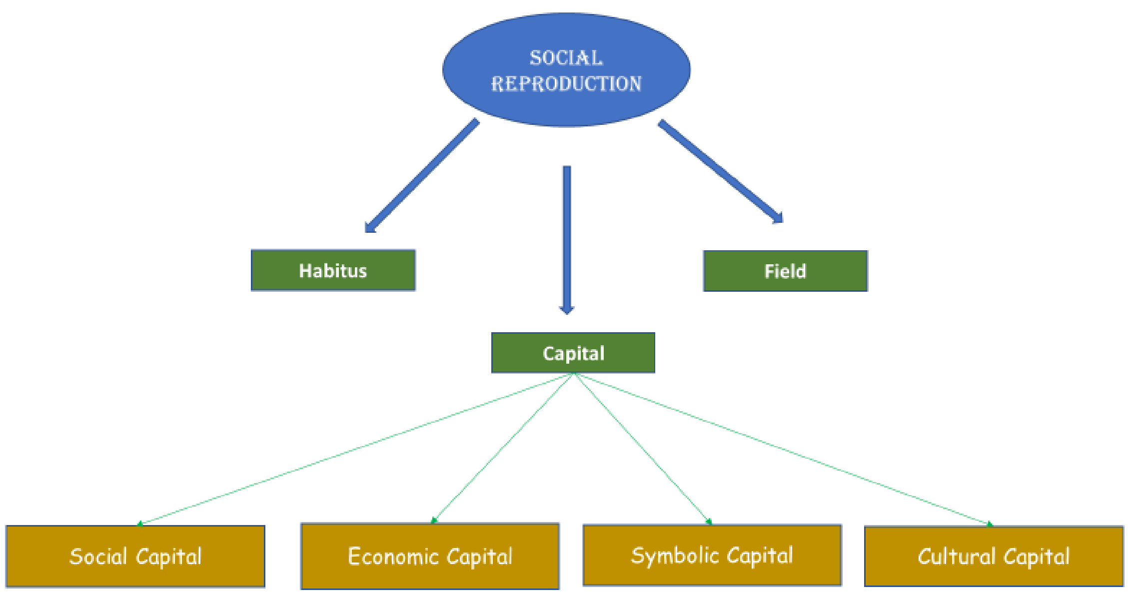

Figure 1. Theoretical Model

Many discipline-related references to capital have been identified in the literature. Specifically, within STEM related fields, Archer, DeWitt, and Willis (2014) examined the concept of science capital and utilized it as a theoretical lens. Their discussion on science capital continued in a subsequent study in which they described, "… ongoing conceptual modelling of what science capital 'is' (how it might be theorized) and how it might be 'measured' via a survey instrument" (Archer, Dawson, DeWitt, Seakins, & Wong, 2015, p. 939). Other researchers explored computer and technological capital (Tondeur, Sinnaeve, van Houtte, & van Braak, 2010), as well as mathematics capital (Jorgensen, 2018). If these discipline related references to capital were to be viewed collectively, they together contribute to the concept of STEM capital. Therefore, STEM capital can be described as STEM assets that individuals gather during their lifetime that translate into benefits within STEM related fields. The concept of STEM capital exists as a framework encompassing Bourdieu's forms of capital, in that the accumulation of STEM capital relies on social, cultural, symbolic, and economic engagements and opportunities.

1.2.2. Identity and STEM Identity

Within the field of education, Gee's identity theory has been utilized extensively (Gee, 1999, 2000). He referred to identity as being recognized as "… a certain 'kind of person' in a given context" (Gee, 2000, p. 99). Gee's description of identity embodied the assumption that that a person can have multiple identities, and these can change depending on the situation or context. "The 'kind of person' one is recognized as 'being' at a given time and place, can change from moment to moment in the interaction, can change from context to context, and, of course, can be ambiguous and unstable" (Gee, 2000, p. 99). There are four aspects of identity that intermingle with each other (Gee, 2000). The first of these is *nature identity* and is related to naturally occurring events in people's lives that are out of their control. One example is that a person could be female and the youngest child in their family. The second perspective is *institutional identity* and is referred to as a position within an institution, such as being a teacher within a school system. *Discourse identity*, the third perspective, is related to individual traits that become recognized as a result of discourse with others. One example is a person's verbalized and gestured positive attitudes might be recognized by others as an association with a particular identity. The final aspect is *affinity identity* and is related to being part of an "affinity group" (Gee, 2000, p. 101), where people share some sort of interest or common feature, such as a science group.

Similar to participating in an affinity group, the idea of "communities of practice" was developed by Lave and Wenger in which they describe how individuals who have shared interests regularly interact with each other in an effort to improve their practices (Lave & Wenger, 1991; Wenger, 1998). "Communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interaction on an ongoing basis" (Wenger, McDermott, & Snyder, 2002, p. 11). Communities of practice encompass domains of shared interest and specific practices that become the focus of the individuals within the community. They aid with the development of affinity identities.

People's identities are not only influenced by their perception of themselves and their competency in completing tasks, but also by how other people perceive them. In an identity framework developed by Carlone and Johnson (2007), three distinct aspects of identity were identified: competency (knowledge in a specific field), performance (social demonstrations of relevant practices), and recognition (how people see themselves and are seen by others). In a later publication, Hazari et al. (2010) added another dimension to the identity framework, interest, and focused the framework on individuals' self-perceptions with respect to competency, performance, recognition, and interest. Subsequent studies combined performance and competency into one construct since they appeared to be indistinguishable for students (Cribbs, Hazari, Sonnert, & Sadler, 2015; Godwin et al., 2016).

One discipline-specific type of identity, referred to as STEM identity, can be described as how individuals view and situate themselves within STEM and how their perception interacts with the recognition they receive from others (Carlone & Johnson, 2007; Collins, 2018; Hazari et al., 2010). The concept of STEM identity can also be viewed as a social identity, where individuals see themselves as part of a community of practice or feel a sense of belongingness to an affinity group (Gee, 2000; Kim et al., 2018; Lave & Wenger 1991). The development of STEM identity has deep roots in early experiences. Some of these experiences may include formal and informal learning opportunities (Dou, Hazari, Dabney, Sonnert & Sadler, 2019; Tyler-Wood, Ellison, Lim, & Periathiruvadi, 2012), as well as early encouragement (Ing, 2014). Positive identity in STEM is vital for pursuing and persisting in STEM related careers (Marsh & Yeung, 1997; Nagy, Trautwein, Baumert, Köller, & Garrett, 2006; Watt, 2006).

1.2.3. Identity Capital and STEM Identity Capital

Building on the relationship between identity and capital, Côté (1996, 1997) developed an identity capital model. He described how his model might be used to view how young people acquire and handle identity so that it can translate effectively into their adult lives. Thus, identity capital is referred to as a representation of "… aspects of who one is that can be invested to successfully navigate key tasks and to capitalize on experiences" (Burrow & Hill, 2011, p. 1196). Côté mentioned that identity resources are sociological and psychological in nature. Sociological investments are tangible and include visible resources like "… conferred identities such as parents' social class/wealth/networks; the person's gender and ethnicity as related to specific social capital contexts; and achieved or attained identities such as the person's earned credentials, peer/professional networks, reputation, and statuses" (Côté, 2016, p. 17). On the other hand, psychological investments are intangible and not easily observed. They include resources such as intelligence, self-esteem, cognitive/moral reasoning abilities, and other personality traits (Côté, 2016).

Although not expanded on by Côté, many tangible and intangible assets can be accumulated early in life, and these resources can be maintained and invested to acquire more resources. For example, if a child has parents employed in a science field (sociological resource), he/she may develop early interest and high self-efficacy in science (psychological resource) leading to a rational decision to pursue a science degree (sociological and psychological resources), and affiliate with a group that has science interests (sociological resource). In attempting to coalesce the concepts of identity and capital within STEM, an appropriate and fitting definition of STEM identity capital would be: STEM resources and assets that have been accumulated over time that serve to develop and motivate STEM identity. Many of these resources and experiences are deemed stable and can persist over space and time as salient components of an individual's existing STEM identity (Wang, Hazari, Cass, & Lock, 2018). *Figure 2* provides a framework reflecting how capital is accumulated through early experiences and how these experiences impact identity. Some of these early experiences persist as identity capital and consistently impact identity through time (e.g. a formative early childhood experience that a person revisits throughout their life to remind themselves of their interest, capability, etc).

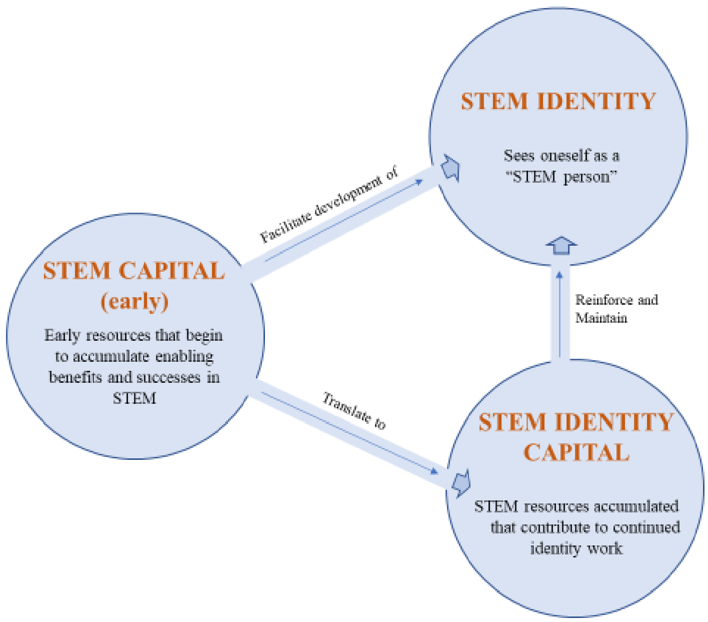

Figure 2. Model of STEM Capital/Identity/Identity Capital

1.3. Chapter Descriptions: Overview of Dissertation Research

My dissertation follows the collected papers dissertation format. Chapters 2, 3 and 4 consist of three papers which have been specifically prepared for publication in scholarly journals. Although these papers address an overarching theme of familial occupations and early STEM experiences and the relationship to STEM identity and career intentions, each paper incorporates self-contained sections related to purpose, theoretical framework, literature review, methods, results, and conclusion.

The key theoretical focus in this 3-paper dissertation is STEM capital and will be utilized as a general lens to gain greater understanding of how students select STEM careers while navigating implicit and explicit early experiences related to STEM. Although STEM capital can be studied as it relates to social, economic, symbolic, or cultural capital, my dissertation will focus on STEM capital as it relates to social capital (e.g. knowing people who have STEM occupations) and cultural capital (e.g. experiences related to STEM). However, this focus does not preclude the fact that these two sources of capital may intermingle with other forms of capital. For example, a family member's employment in STEM might be related to being in the middle and high socio-economic bracket (economic capital) and the family member may have degrees and a reputable position (symbolic capital) assisting with the impact of their influence.

The first paper focuses on implicit experiences (familial occupations) in STEM and their relationship to STEM career intention. The second paper embodies both implicit and explicit experiences (familial occupations and early STEM experiences) and their relationship to STEM identity/identity capital and career intention. The third paper also examines both implicit and explicit components (familial occupations and early STEM experiences) with the goal of explaining the nature of the relationship to identity/identity capital and STEM career intention (*Figure 3*).

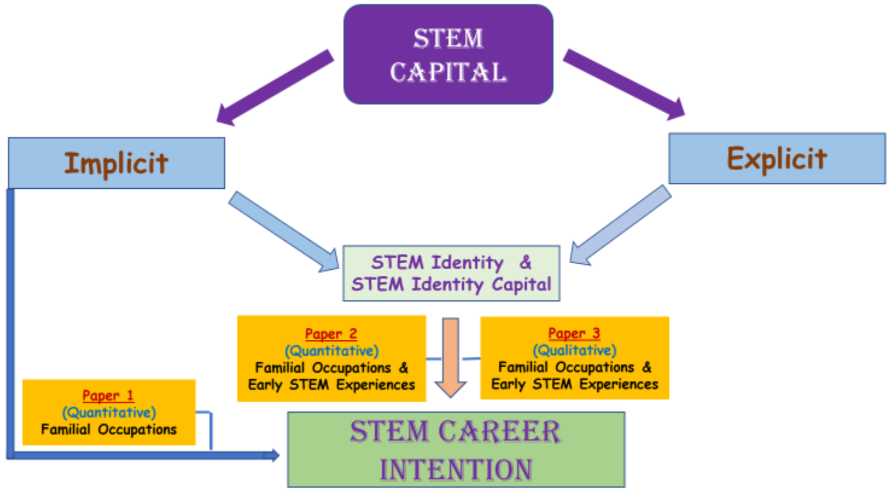

Figure 3. Model of Collected Papers Dissertation

1.3.1. Chapter 2: Examining the Effects of Familial Occupations on Students' STEM Career Intentions: A Gender Study[1]

The first of my three studies looked specifically at familial occupations and the relationship to STEM career intentions. Utilizing the STEM capital lens, my study provided a comprehensive view on how familial occupations might be viewed as STEM capital and suggests that students that may not have family members in STEM may lack this form of STEM capital.

Research Questions:

For a general population of college students:

[1] This article is being formatted for submission to the *Bulletin of Science, Technology & Society*. My coauthors, Zahra Hazari (major professor) and Geoff Potvin (committee member) provided valuable insight and assistance with data analysis and editing.

1. How are family members' STEM occupations associated to students' STEM career intentions?
2. What is the combined effect of having multiple family members (quorums) with STEM careers?
3. What gender differences exist in how family members' STEM occupations are associated to STEM career intentions for female students?

The data utilized for the study were obtained from the Sustainability and Gender in Engineering (SaGE) survey study (NSF Grant Number 1036617). Two regression models were created, one to observe the individual effects, and another to view a quorum effect of having multiple family members employed in STEM occupations. The results from this paper were presented at the National Association for Research in Science Teaching (NARST) Conference in March 2018.

1.3.2. Chapter 3: Exploring the Effects of Familial Occupations and Early STEM Experiences on STEM Identity/Identity Capital: A Gender Study[2]

The second paper in my dissertation addressed the effect of familial occupations and early STEM experiences on STEM identity. While utilizing a theoretical framework of STEM capital, my study also introduced models of STEM identity and STEM identity capital. Furthermore, it tested the relationship between STEM identity and STEM career intentions.

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[2] This article is being formatted for submission to the *Science Education* Journal. Although I completed the preponderance of the study, my coauthors, Zahra, Hazari (major professor), Sonnert Gerhard (Harvard-Smithsonian Center for Astrophysics), Philip Sadler (Harvard-Smithsonian Center for Astrophysics), and Jonathan Mahadeo (graduate student) provided valuable input related to this study.

Research questions:

For a general population of college students:

1. What relationship, if any, exists between STEM identity and STEM career intentions?
2. How are implicit experiences linked to STEM capital, such as familial occupations in STEM, related to STEM identity?
3. How are explicit experiences linked to STEM capital, such as early STEM experiences, related to STEM identity?
4. What differences, if any, exist in the effect of early STEM experiences on STEM identity for female students?
5. Do the significant early STEM experiences translate into STEM identity capital by contributing to STEM identity in college after accounting for middle and high school interest?

The data for the study were obtained from a large research project titled *A Study of How Pre-College Informal Activities Influence Female Participation in STEM Careers* (NSF Grant Number 1612375). Regression analysis was utilized with four different models. Results related to the early STEM experiences were presented at the NARST Conference 2019.

1.3.3. Chapter 4: Phenomenological Case Studies on How Extended Family Occupations and Early STEM Experiences Contribute to Female Students' STEM Identity/Identity Capital[3]

The final paper is qualitative in nature and specifically relates to the lived experiences of female students with STEM majors. My third paper is a continuation of the second study and focuses on the significant variables that were identified in that study.

Research questions:

1. What is the lived experience of familial occupations in STEM (in this case, another relative) and how does this experience relate to female students' STEM identities and STEM career intentions?
2. What is the lived experience of early STEM experiences and how does this experience relate to female students' STEM identities and STEM career intentions? (Early STEM experiences are focused on: *baking/cooking/kitchen chemistry, using STEM toys/kits, watching STEM-related TV programs or movies, playing STEM computer/video games, writing about STEM, observing or studying stars and other astronomical objects, encouragement from father, encouragement from mother, encouragement from elementary school teacher*.)
3. How do these early experiences continue to affect female students' STEM identities years later?

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[3] This article is currently being formatted for submission to the *International Journal of Science Education*. My coauthor, Zahra, Hazari (major professor) provided significant input and edits related to this study.

The data for the study were obtained from surveys and interviews conducted with 16 undergraduate female students majoring in STEM fields. The participants were identified by administering a shortened version of the survey *A Study of How Pre-College Informal Activities Influence Female Participation in STEM Careers*, which included the significant variables that were identified in paper two along with the controls and other demographics. The survey was administered in introductory science courses at a large southeastern university. The study participants were female, intending on pursuing STEM careers, had exposure to specific forms of early encouragement identified in paper 2, and participated in specific early (K-4) STEM activities identified in paper 2.

1.3.4. Chapter 5: Coalescing the Chapters

The final chapter provides a summary of the three papers within this dissertation. It reflects on the progression from analyzing familial occupations as independent variables in the first paper, to adding early STEM experiences as additional independent variables in the second and third papers and viewing similarities and differences in the findings. The intellectual merit provided in this section highlights the use of a nuanced theoretical model that can be easily applied to future research. It also discusses the benefits of knowing the types of experiences that impact identity and serve as identity capital to consistently influence identity across space and time. Several suggestions are provided for teachers and administrators, STEM program leaders and parents. I identify future studies and limitations and emphasize how extensions to the research presented in my dissertation can provide further impact to the field of STEM education.

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CHAPTER 2

EXAMINING THE EFFECTS OF FAMILIAL OCCUPATIONS ON STUDENTS' STEM CAREER INTENTIONS: A GENDER STUDY

2.1. Abstract

The present study investigated the predictive effects of familial occupations on students' STEM career intentions. The data for this study were obtained from a project involving 6772 undergraduate students enrolled in introductory English courses. Two regression models were created, one to observe the individual effects, and another to view a quorum effect of having multiple family members employed in STEM occupations. The results indicate that there was a significant effect for students who had fathers, siblings, and other relatives in STEM occupations. There was a gender interaction effect for sibling's occupation. A significant quorum effect was observed indicating that students who had multiple family members in STEM occupations, were more likely to pursue STEM careers. There was also a gender interaction effect. Results from this study are especially salient for individuals who can assume the role of mentor (e.g., educators, school personnel, parents, and community leaders).

Keywords: STEM career, family occupations, gender

2.2. Introduction

College-age students across the United States are presented with numerous career options. For those who have invested years of thinking and planning, the decision may be quick and easy, while for many the process may be long and arduous where certain careers are discounted prematurely or arbitrarily. Prior research on career intentions has found that students may be influenced by factors such as interest in a specific field (Christensen & Knezek, 2017), teacher support (Watters, 2010), and parental behavior and attitudes (Jacobs & Bleeker, 2004).

Pursuing careers in science, technology, engineering, and mathematics (STEM) fields have gained much attention over the last decade. The US Executive Office has stressed the necessity of improving STEM education and the importance of acquiring jobs in STEM to benefit individuals as well as society (Handelsman & Smith, 2016). For women, STEM persistence has been more difficult, resulting in their underrepresentation in many STEM fields, particularly at the highest levels of academia and the workforce. According to the U.S. Department of Commerce (2017), "Women filled 47 percent of all U.S. jobs in 2015 but held only 24 percent of STEM jobs… women constitute slightly more than half of college educated workers but make up only 25 percent of college educated STEM workers" (p. 1).

The subject of home environments has triggered discussions on factors such as parental education and socio-economic background (Davis-Kean, 2005), as well as family support and sibling relationships (Wegmann, Thompson, & Bowen, 2011). Although some studies have examined how parental occupations in science can influence students' career interests and expectations (Chakraverty & Tai, 2013; Sikora & Pokropek, 2012), there is a need for more nuanced studies to address the impact of different/multiple family members employed in STEM occupations on students' pursuit of STEM careers. The results of such studies, including this one will add to the extant literature by providing a more comprehensive perspective on the effect of familial STEM occupations. The current study utilizes nationally representative large-scale data to examine the effect of having different family members who are employed in STEM fields on college students' STEM career intentions with the effects additionally being compared for women and men.

2.3. **Theoretical Framework**

Pierre Bourdieu developed a theory of social reproduction, that focused on the transmission of inequalities in society (Bourdieu, 1977). Within the social reproduction theory, he explicitly discussed one major component, capital, which is defined as "accumulated labor" (Bourdieu, 1986, p. 241). Capital is associated with resources that become available to individuals enabling them to secure specific benefits and is described as ". . . the legitimate, valuable, and exchangeable resources in a society that can generate forms of social advantage within specific fields (e.g., education) for those who possess it" (Archer, Dawson, Dewitt, Seakins, & Wong, 2015, p. 923). Bourdieu and Thompson (1991) compare capital to the trump card in a card game, in that if you hold the trump card (capital), it guarantees success in the game.

Two forms of capital identified by Bourdieu (1986) are social and cultural. Social capital involves a network and social influences. These influences could include people that an individual might know or recognize within a specific field, and relationships they might form within a group. Specifically, social capital can be obtained by students through familial employment and interactions they have with these family members. Cultural capital highlights background provisions and cultural goods. "Cultural capital refers to accumulated know-how. . . it refers to the knowledge and skills someone has, which gives him/her certain privilege and power over others in certain contexts or communities" (Alshareefy, 2018, p. 65). One example of cultural capital may relate to students participating in numerous out-of-school science activities, as a result of familial interest and employment. Exposure to activities outside of school can enable them to have an advantage of excelling in science classes, and/or having a heightened interest in pursuing a science career. Bourdieu (1977, 1989) believed that cultural capital can be obtained through various structures, such as familial educational background and familial structure, and can be transmitted into educational and economic settings.

Other types of capital have been identified and utilized in discipline-specific studies. Some of these include science capital (Archer et al., 2015; DeWitt, Archer, & Mau, 2016), mathematics capital (Williams & Choudry, 2016), and technological capital (Carlson & Isaacs, 2018). A cumulation of these discipline-specific forms of capital can be seen more broadly as STEM capital. The concept of STEM capital is defined as STEM qualifications, predispositions and resources individuals might have acquired that enable them to have advantages within a STEM environment. Akin to science capital described by Archer et al. (2015), the concept of STEM capital is also influenced by cultural and social factors. For example, individuals with strong STEM capital might have participated in numerous STEM related activities (cultural capital) and know diverse people in STEM fields (social capital).

Some gender studies related to capital indicate that females have more social capital than males (DiPrete & Buchmann, 2013; Riegle-Crumb, 2010). Their social network may include friends, parents, counselors, and teachers. Klevan, Weinberg, and Middleton (2016), noted that social capital is significantly related to college enrollment and that males are disadvantaged in their attainment of significant social capital variables. However, when it comes to STEM related fields, it has been noted that females may have less cultural STEM capital due to decreased expectations from parents (Stoet, Baily, Moore, & Geary, 2016), and ex posure to harmful stereotypes related to STEM (Schuster & Martiny, 2017). Additionally, low capital in general, can transfer into specific disciplines. For example, Archer et al. (2012) indicate that girls with low cultural capital, end up having low science capital.

Although studies have examined how familial occupations in STEM can influence students' career interests and expectations, many of these studies are dated and the labor market has changed with respect to STEM occupations. There is also a need for nuanced studies to address the impact of different/multiple family members employed in STEM occupations on students' pursuit of STEM careers. Additionally, none of the studies discussed in the literature utilized a STEM capital lens to view the influences of familial occupations. Therefore, the current study will provide a new perspective to explore how familial STEM occupations might be viewed as a source of STEM capital and a contributor to STEM career intentions.

2.4. Review of the Literature

Familial Occupational Influences

From children's early years, parents are in a unique position to communicate their values and ideals. The teaching of these values may be direct or indirect, and diverse platforms may be utilized. For example, a parent may directly and explicitly inculcate their child regarding specific behaviors and principles. At other times, their influence may be subtle and indirect, such as acting as role models and enabling observation of their behaviors (Eccles, 1993). Thus, parental influences have significant and far-reaching effects in the lives of children. As children mature, these influences can factor into their decision-making process and guide their career intentions (Simpkins, Fredricks, & Eccles, 2015).

Over the years, women's roles have changed considerably, and the number of employed women has risen rapidly. According to the U.S. Bureau of Labor Statistics (2017), in 1948, 31.3% of women 16 years and older were employed. The employment number rose to 39.6% in 1968 and 53.4% in 1988. By 2010, this number increased to 53.6% and 54.1% in 2016. For all women with children under 18 years, 70.8% were in the labor force in 2016. Furthermore, working women with college degrees jumped from 11% in 1970 to 42% in 2016. Consequently, both parents can now more often serve as professional career role models for their children.

As it relates to STEM occupations, women are underrepresented. They hold 26% of the computer science and mathematics jobs, 14% of engineering, 43% of physical and life science, and 25% of STEM managers (U.S. Department of Commerce, 2017).

However, although within the STEM workforce women are in the minority, those who hold these STEM related jobs still function as STEM career role models.

Previous research has shown that parental occupations can significantly affect their children's career intentions. A study conducted by Mullis, Mullis, and Gerwels (1998) among Caucasian high school freshman revealed that adolescent students whose parents were employed in nonskilled occupations had fewer areas of interests and a limited outlook on career options when compared to students whose parents were employed in skilled occupations. Chakraverty and Tai (2013) reported the contribution of parental occupations on early science interests, stimulating science career intentions. Similarly, Archer et al. (2012) conducted a study with students between the ages of 10-12 as participants and concluded that students with family members in science fields were more likely to pursue science careers than students who did not have family members in science fields. These same results were found for students who had parents in STEM fields (Holmes, Gore, Smith, & Lloyd, 2018).

Same-sex role models have been examined in prior work (Betz & O'Connell, 1992; Sonnert, 2009). In the role model approach, men are influenced by men, and women are influenced by women in regard to occupational intentions. Along these lines, historically, sons followed in the footsteps of their fathers and many acquired the family business or were employed in similar occupations (Saltiel, 1985; Wertz, 1968). The employment trend extended into later decades where significant positive relationships were observed between fathers' occupations and sons' intent to pursue similar careers (Korupp, Sanders, & Ganzeboom, 2002). In a study completed by Schuette, Ponton, and Charlton (2012) among middle school students, there was a strong connection between boys' occupational intentions and male working adults within their home in relation to interests and job gender identification. Another study completed by Van de Werfhorst and Luijkx (2010) showed that males' social selection into careers were influenced by their fathers' occupations.

Likewise, with respect to same-sex influencers, research highlights connections between mothers' occupation to daughters' decisions to pursue similar careers (Basow & Howe, 1979; Rosenfeld, 1978; Treiman & Terrell, 1975). A study completed by Stevens and Boyd (1980) confirmed that daughters whose mothers were employed were more likely to join the labor force and pursue similar jobs, while Jacobs, Ahmad, and Sax (2017) reported strong mother-daughter connections in the field of engineering.

In opposition to the role model approach, the opportunity structure approach, "…asserts that men and women will respond similarly to available opportunity" (Betz & O'Connell, 1992, p. 99). In a study completed by Betz and O'Connell (1992), it was determined that for nontraditional gendered occupations, such as male nurses and female engineers, individuals were influenced by the opposite sex. Similarly, Sonnert (2009) concluded that among a group of female scientists, fathers were referred to more frequently than mothers as influencers. Mothers' occupations also have an effect on their sons' pursuits. In one study conducted by Trice and Knapp (1992) boys' likelihood of pursuing their mothers' careers was apparent if the mothers' and fathers' occupations were of comparable status, or if the mothers' occupational status was higher. Another more recent study was completed by Stoet et al. (2016) among 16-year old students across 68 nations. They reported that in more developed countries, mothers in STEM occupations placed more emphasis on their sons' mathematics achievement and competence than their daughters'.

Siblings can influence students' career decisions by acting as alternative role models and sources of support. Sibling support can be multidimensional in nature and can extend to emotional and informational assistance as well as social integration. Schultheiss, Palma, Pedragovich, and Glasscock (2002) indicate that in addition to career informational support, "… participants turn to siblings for advice and opinions, and as role models, as they prepare for their occupational futures through career exploration and decision making" (p. 308).

Younger siblings have reported higher levels of support, advice, and influence from older siblings. In a study among older adolescents, Tucker, Barber, and Eccles (1997) observed a hierarchical relationship where younger siblings relied on older siblings for information and support based on their perception of older siblings' experience and resources. Furthermore, Martinez and Castellanos (2018) reiterated the importance of older siblings' support in career intentions. In a study related to dyad siblings, Bradley (1984) referred to general rules of career selection. One of these rules indicated that roles adopted in the family can correlate to siblings' career selections. Since older siblings are sometimes tasked with the role as caregiver, they are inclined to select high power (Steinberg, 2001) and managerial (Claxton, 1994; Grinberg, 2015) occupations.

Other relatives, such as grandparents, aunts, uncles, or grandparents can provide educational support. Extended family can contribute to educational success through providing resources to their low-income relatives (Jaeger, 2012), as well as offering affective support (Bengtson, 2001). Grandmothers (Crick, MacDonald, Perry, & Poole, 2017) and grandfathers (Yamson, 2016) can also influence their granddaughters to pursue specific careers.

2.5. Purpose

Although studies have examined how familial occupations in STEM can influence students' career interests and expectations, many of these studies are dated and the labor market has changed with respect to STEM occupations. The present study contributes to the literature by providing recent data related to familial occupations and adding a more nuanced perspective to address the impact of different/multiple family members employed in STEM occupations on students' pursuit of STEM careers.

Therefore, this study addresses the following research questions:

1. How are family members' STEM occupations associated to students' STEM career intentions?
2. What is the combined effect of having multiple family members (quorums) with STEM careers?
3. What gender differences exist in how family members' STEM occupations are associated to STEM career intentions?

2.6. Methods

Data for this study were drawn from a large study on sustainability and gender in engineering (SaGE). The survey was developed by first completing a literature review to determine factors that contribute to enrollment in engineering. Then items were extracted from other national surveys that were previously administered. To develop content validity, an open-ended survey was administered online to 83 high school teachers who were members of the National Science Teacher Association. A test-retest reliability study for the survey with 62 college students confirmed the stability of the survey with a reliability coefficient of 0.7. A stratified random sample of 50 colleges/universities were recruited across the United States based on size and 2-year or 4-year designation to yield a nationally representative sample. The survey was administered in fall of 2011 among STEM and non-STEM majors in required introductory English courses at the recruited schools. Altogether, 6772 students responded to the survey. In relation to gender, 2523 students identified as male and 3,041identified as female. The races that students identified with were African-American or Black, 656; Asian, 471; American Indian or Alaskan Native, 361; Caucasian or White, 3,842; Native Hawaiian or Pacifica Islander, 89; Other races, 523. Additionally, 3,731 students reported being in their first year of college; 816 in their second year, and 329 beyond second year. The survey contained 47 questions and included items such as: demographics, career goals, perceived mathematics and science identity, and high school experiences in science and engineering.

Listwise deletion refers to a process of eliminating whole sets of data if one value is missing (Myers, 2011). When applied to multivariate analysis, the process can result in a significant loss of cases and statistical power. Within this set of data, listwise deletion was not an issue for most of the selected variables. However, in a few cases, elimination of data was non-negligible where 40% of the data were lost. To deal with the issue of data loss, multiple imputations were employed where missing data were replaced with imputed values for multiple datasets. The method of imputing data was proposed by Rubin (1977) and is viewed as a reliable and useful method of handling missing data

(Tabachnick & Fidell, 2007; Van Buuren, 2018). Through this process, "… multiple complete datasets are constructed. Analyses are then repeatedly run… and the parameter estimates are averaged across these discrete analysis" (Myers, 2011, p. 303). Multiple Imputations were completed through R Statistical Software, utilizing the Amelia program (R Core Team, 2019). An additional package, Zelig was used to analyze the data after the imputations were complete (R Core Team, 2007).

In responding to the research questions, a linear regression model was created. The outcome variable of STEM career interest was derived from responses to the item, "Please rate the current likelihood of your choosing a career in the following". Students were then presented with several career options, such as mathematics, environmental science, biology, chemistry, and electrical/computer engineering. For the purposes of the current study, the maximum response value given for all STEM options was used to create the outcome of STEM career intention. The outcome had a range of "0 – Not at all likely" to "4 – Extremely likely".

For family members' professions, the following were combined into the identification of a STEM-related career: medical/health professional; scientist; engineer; and other science, technology, or mathematics related careers. The frequencies for family members with regards to STEM-related careers were: 1302 (mother), 1579 (father), 909 (siblings), and 2324 (other relatives).

A second regression model was created including a predictor that summed all family professions into a quorum variable. The range of the quorum variable was 0, indicating that no family members in STEM-related careers were reported, to 4 where mother, father, sibling, and other relatives were reported having STEM-related careers.

Thus, the frequencies of students that had multiple family members (mother, father, siblings, other relatives) employed in STEM were: 73 (4 family members); 449 (3 family members); 1191 (2 family members); 2093 (1 family member). Thus, a total of 3806 students reported at least one family member with a STEM career representing the quorum variable. While this may appear to be a large proportion of the college student sample, recall that a family member also includes extended family for the quorum measure. Furthermore, a large number of individuals in the United States work in STEM jobs; the U.S. Bureau of Labor Statistics reported that there were 8.6 million STEM jobs in 2015 (Fayer, Lacey, & Watson, 2017). Both regression models controlled for differences in parents' demographics (highest level of education) and students' academics and demographics (gender and race/ethnicity). All data were analyzed with the R statistical software program (R Core Team, 2007, 2019).

2.7. Results

The regression model predicting STEM career intentions with parental occupation is summarized in Table 1. The results revealed that there was a significant effect of father's occupation in STEM ($p<0.001$), sibling's occupation ($p<0.001$), and other relative's occupation ($p<0.01$) for all students. There was no significant effect for mother's occupation in STEM. There was a gender interaction effect for sibling's occupation which revealed that siblings in STEM had no effect for females, but a significant positive effect for males (see Figure 1). Table 2 outlines the results of the regression model predicting STEM career intentions with the combined STEM quorum variable. The results revealed a significant effect ($p<0.001$). There was also a gender interaction effect reflecting a significant positive slope for male students with multiple family members in STEM, while for female students there was less of an effect (see Figure 2). Both regression models had an adjusted R^2 (coefficient of determination) of 0.07.

Table 1

Regression Model Predicting STEM Career Intentions with Family STEM Occupations

Parameters	Estim.	Sig.	SE
Intercept	2.93	***	0.12
Demographics and background controls			
Race		Included	
Ethnicity		Included	
Parental Education		Included	
Gender (0 = Male, 1 = Female)	-0.33	***	0.04
Career Predictors			
Father in STEM	0.23	***	0.05
Sibling in STEM	0.31	***	0.08
Other relative in STEM	0.14	***	0.04
Interaction: Sibling in STEM x Gender	-0.37	***	0.11

*** $p \leq 0.001$

Table 2

Regression Model Predicting STEM Career Intentions with STEM Occupation Quorum

Parameters	Estim.	Sig.	SE
Intercept	2.89	***	0.12
Demographics and background controls			
Race		Included	
Ethnicity		Included	
Parental Education		Included	
Gender (0 = Male, 1 = Female)	-0.29	***	0.06
Quorum Effect	0.19	***	0.03
Interaction: Quorum x gender	-0.10	**	0.04

** $p \leq 0.01$
*** $p \leq 0.001$

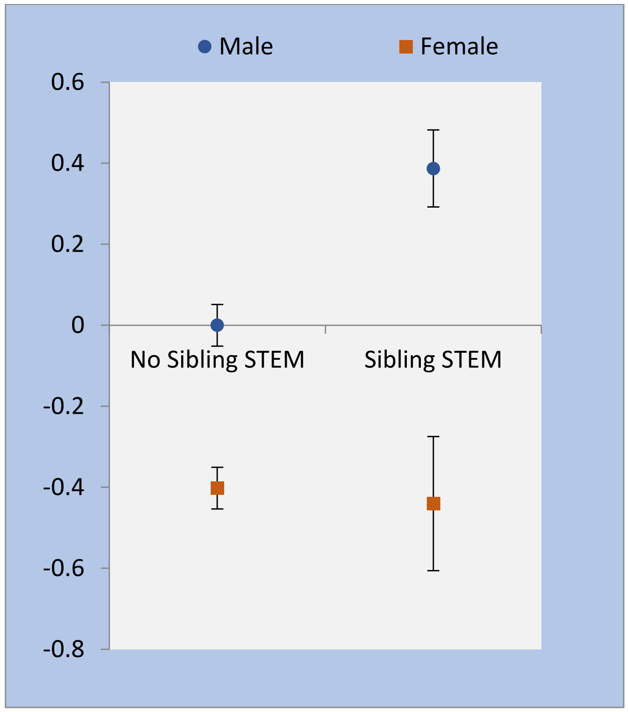

Figure 4. Sibling Gender Interactions

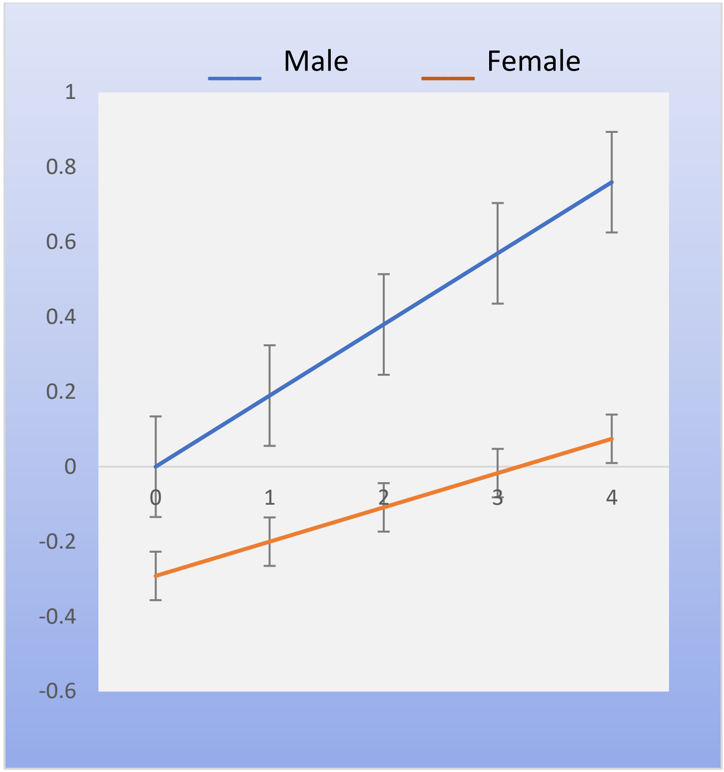

Figure 5. Quorum Gender Interactions

2.8. Discussion

Results from the current study indicate that students who had a father, sibling, and/or other relative in STEM are significantly more likely to intend STEM careers. In viewing these variables individually, it is interesting to note that fathers have been regarded as prominent influencers of their sons (Diamond, 2007; Hebert, Pagnani, & Hammond, 2009) and daughters (Sonnert, 2009). The deep-rooted influence also extends to fathers' employment, where through direct and indirect methods, fathers impact their children's decisions to pursue similar careers. Consistent with previous literature, fathers' influences and occupation are directly related to the career intentions of their sons (Schuette et al., 2012; Van de Werfhorst & Luijkx, 2010) and daughters (Hanson, 2000;

Holland, 1962). Having a sibling in STEM can also be significantly related to students selecting a STEM career since siblings are often seen as offering support and career guidance (Schultheiss et al., 2002; Tucker et al., 1997). Therefore, if they are employed in STEM related fields, they may communicate the future benefits and successes of pursing a STEM career, while offering professional support. The findings in the current study are bolstered by other studies that report siblings pursuing similar careers (Leslie, 2011; Manzoor et al., 2010; Wozny, 2012) or working in the family business (Baines & Wheelock, 1998; Ward, 2004). Likewise, other relatives such as aunts, uncles and grandparents in STEM can influence students through mentorship and guidance (Bengtson, 2001).

In viewing these results through the lens of STEM capital, it is suggested that students that have a father, sibling, or other relative in STEM have more capital than students who do not have these family members in STEM. Students that possess STEM capital might have enhanced cultural capital since they might be exposed to early interaction with STEM activities. One example is that parents who are interested in mathematics are likely to purchase mathematics-based computer games, board games, or manipulatives (Jacobs & Bleeker, 2004). Students with family members in STEM also accumulate social capital having known someone in STEM and being exposed to the network of contacts in the STEM field (Grenfell & James, 1998).

The results also indicate that there was no relationship to mother's occupation in STEM. One possible explanation for the disconnect is that mothers consistently nurture their children and support their future aspirations (Arendell, 2000). These persistent forms of encouragement may overshadow any professional career influences making them indistinguishable from other forms of encouragement. In addition, working mothers are perceived as holding dual jobs; caretakers at home and professional employees (Hesse-Biber & Carter, 2000). Students may unconsciously place more emphasis on the maternal role and may not recognize the full impact of their mothers' professional occupation. These results are consistent with findings from Schuette et al. (2012) where no relationship was found between working women and career intentions of students in the household.

There was a significant interaction with sibling in STEM and gender. When observing males, as the number of family members in STEM are added, a statistically significant positive slope was found. On the other hand, there was no significant difference between females with or without a sibling in a STEM career. One possible explanation for this result may be a sibling gender-match effect. In other words, for male students, having a male sibling with a STEM career has an effect whereas for females, having a female sibling with a STEM career has an effect. Since more males have STEM careers as opposed to females, a greater effect is observed for male students than for female students. Another explanation may be that male adolescents are developmentally more susceptible to the influence of nearer age role models and mentors (Piquero, Gover, MacDonald, & Piquero, 2005). Further research on the effect of siblings is needed to better understand how and why they might influence students' occupational intentions. The sibling interaction embodies how inequalities can be transferred in society, specifically as it relates to women. Males that have siblings in STEM accumulate more STEM capital than females who have siblings in STEM. This rise in capital for males may contribute to the underrepresentation of women in STEM related fields.

A strong, significant effect was observed for having a quorum of family members with STEM careers for both male and female students. The significant effect suggests that the more family members with a STEM career, the greater the likelihood for a student to intend a STEM career. Therefore, individuals that have multiple family members in STEM will accumulate more STEM capital. Opportunities for accumulating capital may present themselves from engaging in more STEM related activities provided from multiple familial resources. For example, both parents in STEM careers may consistently encourage participation in informal learning experiences such as visiting museums and parks or they may provide the student with a plethora of STEM games and resources. There may also be more exposure to STEM through everyday experiences within the home environment such as more talk about STEM around the dinner table or more STEM related books and journals present within the home.

Finally, there was a significant interaction effect between the quorum and gender variables. The results reveal a significant positive slope for males with family members in STEM. For female students the slope was significantly less than male students indicating that the quorum has less of an effect for women. One possible explanation could be that since more males are in STEM related careers than females, these occupational influences might come from multiple (largely male) family members. Since studies highlighting the same-sex influencer role model approach indicate that women are influenced by women in regard to occupational intentions (Betz & O'Connell, 1992; Sonnert, 2009), having multiple (largely male) family members in STEM would likely have less effect on female students' intent to pursue STEM careers. In addition, studies indicate that some family members in STEM are more inclined to encourage male rather than female students to pursue STEM related careers (Stoet et al., 2016). Therefore, if multiple family members are employed in STEM related careers and male students receive more encouragement and support to pursue STEM related careers, females will not benefit as much from having a quorum of family members in STEM.

Both regression models in this analysis only explain 7% of the total variance in STEM career intentions. The lack of relationship has both negative and positive implications. On the one hand, it emphasizes the complexity of STEM career intentions and the fact that there are many possible factors in addition to family careers that influence these intentions (Jacobs, 2005). Understanding all these factors is not an easy task. On the other hand, since the effect is small, other role models, such as, educators, and community leaders have the capacity to compensate for inequities determined by familial careers through other forms of career support and mentorship.

2.9. Limitations and Future Studies

The current study has some limitations. To begin with, the survey questions utilized in this study are self-reported, allowing for susceptibility to selective recall and social desirability biases (Fadnes, Taube, & Tylleskär, 2009). In addition, the survey did not solicit responses for familial length of time in STEM occupations. Therefore, there is no way to determine when students were exposed to familial career influences or the depth of this influence over time.

The findings from the study can be shared at workshops and conferences and will assist potential role models, such as, educators, school personnel and community leaders, in how they approach and encourage students who might have beginning interests in STEM, but lack capital that could have been accumulated from their interactions with family members employed in STEM related fields. It will remind them of their salient role as mentors and will bolster their interactions with the students. In addition, through publication, the current study will add to the literature by providing focus on nuanced areas of familial occupations, such as having multiple family members in STEM related professions. It will also inform forthcoming research involving novel approaches and frameworks of viewing familial occupations.

Future studies will focus on determining the relationship between familial STEM occupations and identity, identity capital, and career intentions. Emphasis on these constructs will allow for application of new lenses in viewing how having family members employed in STEM might affect students' identity development and career intentions. A qualitative perspective will also be utilized to ascertain how female students view familial STEM occupations and the relationship to their identity development and career intentions.

Conclusion

The issue regarding creating a strong STEM workforce that can sustain a growing modern economy is compelling. Equally salient is the ability to attract and retain males and females alike within the STEM employed community. The current study addresses some of these concerns by pinpointing factors that influence STEM career intentions and utilizing large scale data to focus on one specific factor, familial occupations. The findings confirm that a significant relationship exists between familial occupations and STEM career intentions with sibling and quorum gender interactions. These results suggest that students who come from households where STEM careers are prevalent likely possess capital towards STEM. This information is especially applicable to individuals who can assume the role of mentors (e.g., educators, school personnel, community leaders, and parents in non-STEM careers). They can fill the gap for students lacking family occupation influences by stimulating interest and involvement in STEM and acting as positive role models and guides. Specific attention should be given to young women, who are underrepresented in STEM fields. Positive STEM interactions with role models can assist females by increasing interest, building STEM identity and bolstering persistence in STEM related fields.

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CHAPTER 3

EXPLORING THE EFFECTS OF FAMILIAL OCCUPATIONS AND EARLY STEM EXPERIENCES ON STEM IDENTITY/IDENTITY CAPITAL: A GENDER STUDY

3.1. Abstract

This study utilized a Science Technology Engineering and Math (STEM) identity theoretical framework to examine the effect of familial occupations and early STEM experiences. It was also guided by nuanced perspectives on STEM capital and STEM identity capital. The data used for analysis for this paper were derived from surveys that were administered to 15,725 students enrolled in introductory English courses. Four blocked regression models were applied, and the results indicated a significant effect for students who had another family member in STEM, as well as those who received encouragement in STEM from parents and elementary school teachers. Specific early experiences were positively related to STEM identity, such as, watching STEM-related TV programs or movies. Many early experiences also existed as STEM identity capital and served to consistently impact identity across space and time. There are salient implications for administrators and educators related to STEM activities/experiences they introduce to students.

Keywords: STEM capital, STEM identity capital, early STEM experiences, family occupations, early encouragement

3.2. Introduction

The topic of science, technology, engineering, and mathematics (STEM) identity has been increasingly discussed over the past decade with a continued urgency for understanding its development, particularly for groups who have historically been marginalized in STEM fields. Although there are many aspects to STEM identity, it often refers to students' "…ability to see themselves as the kind of people who could be legitimate participants in STEM through their interest, abilities, race, gender, and culture" (Hughes, Nzekwe, & Molyneaux, 2013. p. 1980). Prior research has investigated how STEM identity relates to STEM career intentions with several studies indicating that students with a STEM identity tend to enroll in STEM courses at the college level (Nagy, Trautwein, Baumert, Köller, & Garrett, 2006), and inevitably select STEM careers (Bieri Buschor, Berweger, Keck Frei, & Kapper, 2014). Researchers have also looked for factors that influence the development and nurturing of STEM identity and identified, among others, academic achievement (Casey, Nuttall, & Pezaris, 1997; White, DeCuir-Gunby, & Kim, 2019) and class/school relations (Brickhouse, Lowery, & Schultz, 2000).

Two particularly important factors associated with STEM identity development in the early formative years are familial occupations and early STEM experiences. Although studies related to familial occupations are limited, other aspects of the home environment are widely discussed. Some of these include socio-economic status (Buldu, 2006; Niu, 2017; Svoboda, Rozek, Hyde, Harackiewicz, & Destin, 2016) and parental beliefs (Del Río, Strasser, Cvencek, Susperreguy, & Meltzoff, 2019; Simpkins, Price, & Garcia, 2015). Likewise, in relation to STEM experiences, many connected studies have addressed middle and high school STEM experiences and their relationship to STEM identity (Brickhouse, et al., 2000; Lock & Hazari, 2016). While these studies related to home environment and middle and high school experiences are necessary and provide significant insight into the development of STEM identities, there is a need for more nuanced studies that specifically address familial occupations and earlier STEM experiences (K-4), especially with respect to gender differences. Focusing on these types of studies is particularly salient because the gendering of beliefs about innate abilities has been found to emerge during these early years and such beliefs are related to participation in STEM (Bian, Leslie, & Cimpian, 2017). In addition, many studies that examine STEM identity formation in the early years are qualitative studies (Kane, 2016; Varelas, Martin, & Kane, 2012). As such, the current study provides a quantitative perspective on the effect of familial occupations and early experiences on STEM identity at later stages, with a particular focus on the experiences that may be important for female students. Given that female students' beliefs in their own abilities with respect to STEM begin to erode at an early age (Lloyd, Walsh, & Manizheh, 2005; Muzzatti & Agnoli, 2007; Saucerman & Vasquez, 2014), these findings will be beneficial to educators for supporting young female students both inside and outside of the classroom.

While this study takes a STEM identity theoretical perspective to examine the effect of early STEM experiences, it also guides the present work with the conceptual frameworks of STEM capital (Bourdieu, 1977, 1989) and STEM identity capital (Côté, 1996). Prior work has emphasized the resources, both visible and "invisible," that students from certain backgrounds access, are necessary in order to construct and maintain STEM identities with ease (Archer, Dawson, Dewitt, Seakins, & Wong, 2015; Archer, et al., 2010; Kane, 2016). It is important to understand the nature of these resources not only in terms of the development of STEM identities but also in terms of how they may be continually accessed to maintain STEM identities. Drawing on a national survey study of college students (who reported on their early STEM experiences and current STEM identities), aspects of early STEM capital (familial occupations and early experiences) with respect to future STEM identity are examined, identifying those aspects with the most significant relationship to STEM identity. Furthermore, these aspects of early STEM capital are tested to ascertain if they continue to have a relationship with STEM identity in the face of intervening middle and high school experiences with STEM since there is a considerable time lag between early experiences and college. The experiences that continue to have an effect on STEM identity despite intervening experiences can be theorized as lending to students' STEM identity capital or the resources that may be used to help maintain STEM identities well into the future. The goal of the present work is to begin to identify the early experiences that help form STEM identity capital in order to better understand long-term persistence in STEM.

3.3. Review of the Literature

Familial Occupations

Parents play a vital role in imparting knowledge and values to their children (Eccles, 1993). These values and beliefs can be communicated clearly, through regular conversations and encouragement (Simpkins, Davis-Kean, & Eccles, 2005), or implicitly through role modeling or similar effects (Eccles, 1993; Jacobs & Bleeker, 2004). These influences are profound and can affect students' future interests and choices. In a study conducted by Jacobs and Bleeker (2004) related to developing interests in math and science, it was ascertained that parental modeling of behaviors and attitudes were related to students' future involvement in and beliefs about mathematics and science.

Parents' occupations can also influence students' pursuit of similar careers. Fathers have been found to influence their sons' careers (Korupp, Sanders, & Ganzeboom, 2002), while mothers have been found to influence their daughters (Hartung, Porfeli, & Vondracek, 2005; Rosenfeld, 1978). More recent studies reflect a change in this trend and report fathers influencing their daughters (Van de Werfhorst & Luijkx, 2010) and mothers their sons (Stoet, Bailey, Moore, & Geary, 2016). Regardless of the source of influence (mother or father), it has been ascertained that parents, in general, who are involved in STEM careers can enable their children to develop an interest in and enthusiasm for STEM activities: "…parents or other caregivers who have a STEM career may share their STEM knowledge and interest with their children, promoting learning and engagement with STEM concepts" (Sheehan, Hightower, Lauricella, & Wartella, 2018, p. 3)

In relation to siblings during the early years, the relationship between younger siblings and older siblings is hierarchical in nature, "… the age difference and order of appearance in the family dictate a formal rank ordering. Therefore, older siblings are considered to be physically, socially, and cognitively advantaged over their younger siblings" (Campione-Barr, 2017, p. 9). Additionally, Wall-Wieler and Roos (2017) reveal a relationship between older siblings' educational attainment and younger siblings' educational attainment. As a result of the relationship, older siblings can be positive role models for their younger siblings and influence their career decisions (Schultheiss, Palma, Pedragovich, & Glasscock, 2002). Other relatives, such as grandparents, can influence students as well. They can provide cognitive stimulation for students and emotional support for parents (Dunifon & Kowaleski-Jones, 2007). Aunts and uncles can also serve as positive role models and encourage students (Loury, 2006).

There is a gap in the literature related to familial occupations in STEM and how it relates to STEM identity and career intentions. Some of the studies that do provide insight, fail to address the current state of the STEM workforce. Additionally, few studies within the existing literature utilize capital lenses to examine familial occupational influences. Therefore, the present study will provide a new perspective to explore how familial STEM occupations might be viewed as a source of STEM capital and a contributor to STEM identity capital.

Early STEM Experiences

Early STEM learning and interest may originate from experiences in diverse settings. One of these might be within a formal classroom environment where students become involved in active learning experiences (Carlone & Smithenry, 2014; Watters & Diezmann, 2016). In an effort to provide early STEM experiences, teachers may choose traditional, didactic forms of STEM teaching, such as lecturing and/or textbooks (Kartikasari, Roemintoyo, & Yamtinah, 2018), or they may select other modern student-centered approaches, like inquiry-based learning (Sadi & Cakiroglu, 2011). Another way that students may gain early STEM experiences is through participation in after school programs. These programs may be funded and focus on a particular area, such as engineering and robotics (Karp & Maloney, 2013) or nature (Camasso & Jagannathan, 2018). Some after school programs are gender specific. For example, the Girls Who Code clubs offer opportunities to learn computer coding and focus on 3rd – 12th grade girls

(Abdul-Martin, 2014; Saujani, 2017). An additional way that students might have access to early STEM experiences is through their home environment. These experiences may emerge as a result of everyday activities where parents draw connections to STEM with students as they prepare meals (e.g., mixing solutions) or participate in grocery shopping (e.g., calculating cost, identifying types of produce). At other times, students may have STEM experiences through their leisure activities at home, such as watching science-related programming, playing video games, or reading science related material (Korpan, Bisanz, Bisanz, Boehme, & Lynch, 1997).

Regardless of where early STEM experiences originate, understanding the importance of these experiences and their relationship to constructing STEM identity is vital. Pantoya, Aguirre-Munoz, and Hunt (2015) conducted a study among 3-7-year-old students and determined that through specific reading and drawing activities, students began forming engineering identities. Likewise, Yoon, Dyehouse, Lucietto, Diefes-Dux, and Capobianco (2014), reported the positive effects of an integrated science, technology, and engineering program on 2nd, 3rd and 4th graders engineering identity and knowledge. Additionally, Tran (2018) reviewed the positive effects of computer programming on elementary students' STEM career intentions. Within elementary classrooms, children have been found to develop mathematical identity (Wood, 2013), as well as environmental identity (Tugurian & Carrier, 2017). Science identity can be constructed and shaped as students engage in early science experiences (Brickhouse et al., 2000).

Constructing STEM identity in the early years as well as consistent nurturing during subsequent schooling years can lead to persistence in STEM fields (Godwin, Potvin, Hazari, & Locke, 2016). Studies reveal that students with positive STEM identity enroll in STEM courses at the college level (Nagy et al., 2006) and inevitably select STEM careers (Bieri Buschor et al., 2014; Dou, Hazari, Dabney, Sonnert, & Sadler, 2019). Additionally, being engrossed and deeply interested in a specific STEM activity can create an emotional state in the early years that can be readily remembered later in life, triggering memories that can reinforce STEM identity and lead to persistence. Wang, Hazari, Cass, and Lock (2018) indicate, ". . . certain memories from a physics class may be drawn upon when faced with physics-related challenges in the future (in college) such that students maintain their physics identities and persist rather than dropping out" (p. 1544). The retention and recall of these episodic memories can enable students to better navigate STEM experiences, irrespective of circumstances, allowing for STEM success and ultimate pursuit of STEM careers.

While early STEM experiences are clearly important for affective outcomes such as identity, there are gender differences in how students experience STEM. One such example is evident in a study completed by Alexander, Johnson, and Kelley (2012), which identified early science interest to be predictive of girls', not boys' achievement, and to be especially important to girls' identity development. Furthermore, in looking at specific early STEM related activities, it has been noted that elementary school boys have beliefs about their superiority in technology (Beisser, 2005) and mathematics (Cvencek, Meltzoff, & Greenwald, 2011). In subsequent years, boys also participate in more tinkering (Jones, Ruff, & Paretti, 2013) and astronomy-related activities (Bergstrom, Sadler, & Sonnert, 2016). Additionally, 6th grade boys are more interested in engineering careers than girls (Dare & Roehrig, 2016). On the other hand, elementary girls showed more positive attitudes and self-efficacy toward stereotypically gendered activities such as cooking (Lohse, Cunningham-Sabo, Walters, & Stacey, 2011).

Although the existing studies on the effects of early STEM experiences provide valuable insight into the nature of these experiences and how they can affect STEM identity, most do not address a wide variety of K-4 experiences (e.g., K-4 education), such as those that are hands-on, technology-based, and/or nature-based. The present study will add to the literature by not only addressing a plethora of early STEM experiences, but also providing a novel perspective on how they can be viewed as STEM capital. The addition of STEM identity and STEM identity capital to the theoretical perspectives will allow lenses to see how early experiences can serve as tangible and intangible resources and how they might be maintained and transferred beyond middle and high school, thereby influencing college STEM career intentions.

3.4. Theoretical Framework

Capital and STEM Capital

Pierre Bourdieu, a French sociologist, had an avid interest in how power was transferred and maintained in society. He developed a framework in which he explicitly discussed three major components of how power is transferred within a structure or domain: *habitus, field*, and *capital*. *Habitus* focuses on internalized dispositions that are produced through interactions and which solicit specific behaviors (Bourdieu, 1977, 1989, 1991). It is sometimes described as a "…feel for the game" (Bourdieu, 1990, p. 90) and assists with developing an "… understanding of 'what is normal for people like me', a set of dispositions that frame ways of thinking, feeling and being and which thus guide current and future actions and possibilities" (Archer, Dawson, Seakins, & Wong, 2016. p. 920). *Field* is the social context, which may include environments such as, education, religion, and law. Bourdieu saw "fields" existing independently of each other and functioning under individual rules and practices (Grenfell & James, 1998). *Capital* refers to resources that individuals accumulate throughout life that allow them to have clear advantages in society. Bourdieu (1986) identified four forms of capital: social, economic, symbolic, and cultural. Social capital is described as the social assets that an individual might accumulate through networking and associating with groups and institutions. "Social capital is the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships." (Bourdieu, 1986, p. 248). Economic capital refers to financial assets, such as money and income, materials, and/or property. Symbolic capital embodies status and prestige, which include degrees and awards obtained, as well as recognition in a specific field. Cronin (1996) discussed how this form of capital can be associated with promotion, prizes, and distinction. Cultural capital refers to the advantages that an individual has in society and could be in the form of education, skills and knowledge. "Cultural capital is cultural knowledge and experience, acquired over time, from family, friends, mentors, or teachers that impart status, dispositions, cultural and linguistic expertise and credentials" (Hinton, 2015, p. 303). Akin to capital, STEM capital focuses on skills and resources that people gather throughout life that enable them to have specific benefits and successes within STEM fields.

In the process of acquiring STEM capital, students may have both implicit and explicit experiences with STEM. During implicit experiences, individuals do not partake in first-hand experiences; rather, they are influenced by others' experiences (e.g. occupations of parents and family members, parental interests, etc.). On the other hand, explicit experiences are less ambiguous, and the participant has a direct involvement in those experiences. For such experiences in STEM, students become active participants and gain knowledge directly through their participation (e.g. conducting a science experiment, solving mathematical puzzles).

In the current study, the key theoretical focus, STEM capital will be utilized as a general lens to gain a better understanding of how students develop STEM identities (and ultimately select STEM careers) through implicit and explicit experiences related to STEM. Although STEM capital can be studied as it relates to social, economic, symbolic, or cultural capital, this paper will focus on STEM capital as it relates to social capital (e.g., knowing people who have STEM occupations) and cultural capital (e.g., experiences related to STEM).

STEM Identity and STEM Identity Capital

The identity of an individual can be greatly influenced by social, economic, symbolic, and cultural capital (Côté, 1996, 1997). The experiences people have based on resources afforded to them influence their identity development and how they view themselves. Gee (1999) indicates that identity is, "…the 'kind of person' one is seeking to be and enact in the here and now" (p. 13). He recognized identity in four states: Nature (state – forces of nature), Institutional (position – authorities within institutions), Discourse (individual trait – by rational individuals), and Affinity (experiences – powered by affinity groups). These states may overlap and co-exist at any given time (Gee, 2000), meaning that individuals may hold multiple identities simultaneously. For example, an individual may identify as a mother, a student, of Asian heritage, and female. Likewise, these identities may have different effects depending on the context/situation. Hazari, Cass, and Beattie (2015) posited forms of these multiple identities, with the inclusion of personal, social, and disciplinary (physics) identities.

Identity is not static; it is fluid and can evolve over space, time, and contexts (Avraamidou, 2014; Gee, 2000). For example, the identity an individual might have as a teacher may have evolved from the identity she/he had as a student. Identity can also be described as dynamic and situationally emergent (Carlone & Johnson, 2007). While there are many possible aspects of science identity, Carlone and Johnson provided a grounded model of science identity that focused on three dimensions: Performance, Recognition, and Competence. Performance entails social performances of scientific practices. Recognition refers to how one recognizes themselves in science as well as how they are recognized by others. Competence refers to one's belief in their science content knowledge. In further developing the identity model, Hazari, Sonnert, Sadler, and Shanahan (2010) added another dimension, interest, when studying high school physics students. Drawing on prior identity work, STEM identity is framed as how students see themselves with respect to STEM as a result of how they are seen by others, their interest, and their beliefs about their own capabilities in STEM.

Connecting identity to capital, an individual's identity formation and maintenance are dependent not only on their experiences in the moment but also their identity capital, i.e. accumulated resources that help maintain or develop their identity. Addressing the maintenance of identity is salient and underscores why Côté (1996) created an identity capital framework because of his concerns regarding the pressure placed on teens and young adults struggling through identity transitions within an unsupportive environment. According to Côté, identity capital is used to describe "… what individuals 'invest' in 'who they are'. These investments potentially reap future dividends in the 'identity markets' of late modern communities" (p. 425). These investments into the identity market are two-fold, sociological and psychological. Sociological aspects may include tangible assets that are typically visible such as, degrees, memberships and appearance. These assets serve to create social advantages. "Tangible resources should be effective as 'passports' into other social and institutional spheres" (Côté, 1996, p. 426). Furthermore, it is argued that sociological identity capital within a particular domain (STEM) allows individuals to maintain and reinforce their domain-specific identities. For example, when challenged about one's expertise in a domain, an individual may reflect upon the fact that they have a degree in that domain to help them maintain and stabilize their domain-specific identity.

Psychological aspects of identity capital are mostly intangible, and thus less visible. These include assets such as, self-efficacy, critical thinking skills, and other internal traits. Lewis (2016) describes these assets as including "… self-esteem; locus of control; sense of purpose; cognitive flexibility; moral reasoning; agentic personality tendencies; and the capacity for self-monitoring" (p. 194). Individuals with low identity capital generally lack intangible assets (Côté, 1996). Therefore, identity and identity capital are viewed as multifaceted and rely on many components such as cultural capital, social capital, and symbolic capital. In the science education literature, identity capital has been referred to as individuals' resources for engaging in "identity work" (Barton, Kang, Tan, O'Neill, & Bautista-Guerra, 2013; Carlone, Scott, & Lowder, 2014). Similar to sociological identity capital, psychological identity capital also enables identity development and maintenance.

In determining when "investment resources" may be obtained by individuals, it is evident that these can be acquired in early years and consistently reinforced. Parents are influential in providing tangible resources, such as financial support, but for younger students intangible resources in the form of emotional and informational support might be more applicable (Tikkanen, 2016). Thus, having "… a more privileged upbringing would be related to greater identity capital acquisition" (Côté, 1997, p. 578) and aspects of identity capital can transfer into adulthood in ways that are meaningful for identity maintenance.

Identity capital resources may not be acted on immediately, and individuals must internalize, accept, and demonstrate them. According to Côté (2005), "… these resources can have an inoculation quality in the sense that they can enable people to reflexively resist and/or act back upon certain social forces impinging upon them" (p. 226). Numerous studies have been conducted among adolescent students (Gross & Rutland, 2016; Hall, 2011; Tikkanen, 2016) and young adults (Luyckx, De Witte, & Goossens, 2011; Oliveira, Mendonca, Coimra, & Fontaine, 2014), reflecting on their preparedness and acquisition of identity capital to be successful in society.

In the current study, STEM identity is defined as the type of person individuals see themselves as, in relation to STEM. Specifically, the definition from Collins (2018) is employed: “STEM identity is the ways in which one views himself or herself based on a belief in his or her ability to utilize STEM skills and/or STEM talents to become a STEM professional or STEM innovator” (p. 146). Bringing the idea of identity capital to bear, STEM identity capital can be conceptualized as the STEM resources individuals accumulate, both sociological and psychological, that assist with their STEM identity development and maintenance.

Although a large amount of research surrounding identity capital has focused on high school students and their transition to adulthood (Luyckx, et al., 2011; Oliveira, et al., 2014), it is imperative to note that accumulation of assets as identity capital may very well be rooted in early years. In the case of early STEM experiences, students may begin accumulating cultural capital and tangible assets through becoming members in STEM programs, and/or utilizing financial resources to open avenues for early STEM experiences. In the case of intangible assets, students may begin to form high levels of self-efficacy (Tran, 2018) and identity (Pantoya et al., 2015) in STEM, and start developing the ability to monitor their progress. Students’ early experiences in STEM can create interest (Alexander et al., 2012), and with proper maintenance portions of their early tangible and intangible assets in the form of early STEM experiences can transition to adult life.

The theoretical model that is identified in Figure 6, represents how these constructs are connected. Students begin accumulating STEM capital early in life enabling them to have benefits and successes in STEM while contributing to the development of their STEM identity. For example, students’ participation in specific

STEM activities can lead to improved academic performance and understanding of STEM concepts in a classroom environment (Ekwueme, Ekon, & Ezenwa-Nebife, 2015) and contribute to increased interest and self-efficacy in STEM (Gibson & Chase, 2002; Richardson, Hammrich, & Livingston, 2003). Specific early STEM experiences might be impactful and unforgettable. Although, these significant experiences may automatically bolster students' identity in STEM, many of them may be so meaningful and/or positive that students consistently repeat and reflect on them during their K-12 school years and beyond (Maltese & Tai, 2010; Wang et al., 2018). The constant repetition and reflection continually reinforce and impact students' STEM success and identity development/maintenance, leading to these experiences being labeled not only as contributors to STEM capital, but also to STEM identity capital. Therefore, STEM identity capital is seen as a component of STEM capital that translates into identity maintenance.

To further explain how the three components in the model work, the following two cases are provided: A group of elementary students participate in an after-school STEM program (STEM capital). Through their involvement, their interest and confidence are affected in the moment, thereby impacting their STEM identity. However, after the program is complete, the students forget about the experience. They have no emotional connection to the experience and there is nothing impactful enough to reflect on later. Therefore, their experience in the after-school program (STEM capital) contributes to their STEM identity, but **not** to their STEM identity capital. On the other hand, another group of elementary students are involved in a similar after-school STEM program. The program affects their interest and confidence in the moment, thereby impacting their

STEM identity. However, unlike the first group they have emotional connections and are highly impacted by their participation. Therefore, they draw on their experiences in the after-school STEM program in later years (middle, high school and beyond), where they reflect on how it impacted their interest and built their confidence. They may remember specific positive moments in the program and their reflection on these moments bolsters their current STEM identity. In this case, their involvement in the STEM after-school program (STEM capital), not only affected their STEM identity, but continues to impact and maintain their current identity (STEM identity capital).

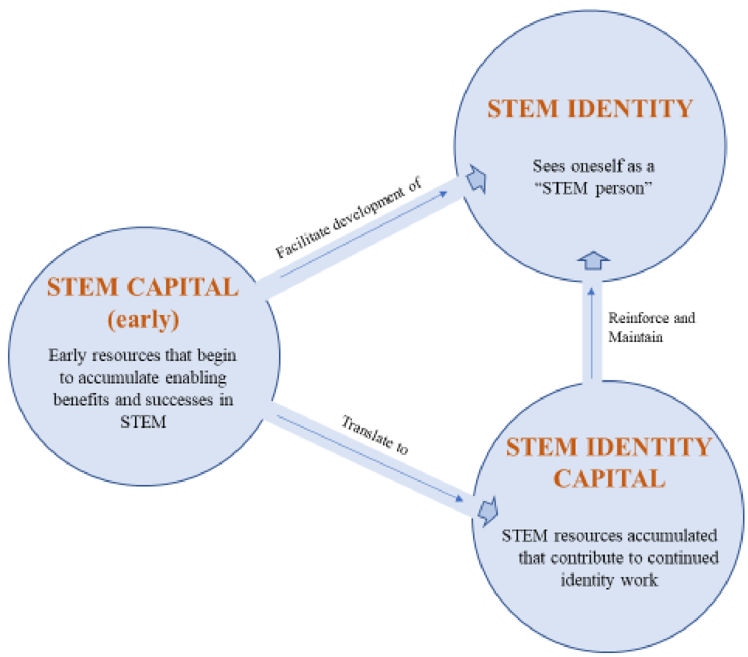

Figure 6. Model of STEM Capital/Identity/Identity Capital

3.5. Purpose

The current study utilizes the STEM capital lens detailed above, as well as the identity framework developed by Carlone & Johnson (2007) and expanded by Hazari et al. (2010). The framework guides the development of the construct for STEM identity defined by STEM competence/performance, recognition and interest, as well as examines the relationship between STEM identity and STEM career intentions. Additionally, STEM identity capital resources, in the form of early STEM experiences, are analyzed through middle and high school, and early college, to detect the stability and influence of these resources across space and time on students' STEM identity. Considering the underrepresentation of women in STEM fields, these lenses become especially salient. They provide a nuanced perspective in understanding the relationship between female students' STEM identity capital and STEM identity development and how the relationship affects their STEM career intentions. Furthermore, they distinguish between those resources (capital) that lend to general success and identity development as compared to those resources that continue to sustain identity over time (identity capital).

The present study addresses the following research questions for a general population of college students:

1. What relationship, if any, exists between STEM identity and STEM career intentions?
2. How are implicit experiences linked to STEM capital, such as familial occupations in STEM, related to STEM identity?

3. How are explicit experiences linked to STEM capital, such as early STEM experiences, related to STEM identity?
4. What differences, if any, exist in the effect of early STEM experiences on STEM identity for female students?
5. Do the significant early STEM experiences translate into STEM identity capital by contributing to STEM identity in college after accounting for middle and high school interest?

3.6. Methods

The data for the quantitative study were collected from a large research project titled *A Study of How Pre-College Informal Activities Influence Female Participation in STEM Careers* (NSF Grant Number 1612375). Utilizing stratified random sampling, 119 colleges/universities across the United States were recruited based on size and type of school (2-year or 4-year designation). The survey was administered in Fall 2017 to first year college students within the recruited schools. Altogether, 15,725 students responded to the survey. Within the data set, 54% of the students identified as female, 45% identified as male, and 1% identified as other. This variable was recoded as 54% female and 46% non-female (consisting of mostly male-identified students). Additionally, the following races were identified: Black (14%), White (66%), Asian or Pacific Islander (17%), American Indian or Alaskan Native (3%), and other (7%) (note that students could select multiple races). 7% identified with more than one race and 24% identified as Hispanic.

The survey included 33 questions, some of which had multiple parts. The items in the survey surrounded many aspects of STEM, such as career intentions, early experiences, participation in programs, and identity. The survey took between 15-20 minutes to complete. The R statistical software program (R Core Team, 2007, 2019) was used to analyze all data in the study. Reliability of the survey items were assessed through a test-retest study with 137 undergraduate students enrolled in introductory English classes at a large university in southern United States. Each student completed the survey twice, separated by two to three weeks. The results indicated reliability coefficients for item blocks ranging from 0.4 to 0.9, viewed as acceptable to high when analyzing groups of 100 students (Thorndike & Thorndike-Christ, 2010). The average reliability for linear items using Pearson correlations was 0.7, which is considered acceptable (Drost, 2011). The average reliability for nonlinear items using Spearman correlations was 0.5. Thorndike and Thorndike-Christ argue that this level of reliability is acceptable for sample sizes of 100, since "With a reliability of .50, the probability of reversal is already down to … 1 in 2,500 for groups of 100" (p. 140). Evidence for face/content validity was collected through expert review.

Missing Data

Within the current dataset, there is missing data. In some cases, these numbers were non-negligible (between 24% and 27% missing data). Furthermore, as common in multivariate analysis, when many variables are considered simultaneously, large numbers of respondents can be excluded even if only one variable is missing for any given respondent. In the current study, exclusion was evident when a STEM identity proxy was created from combining the individual identity variables, leading to 34% of respondents having missing responses to at least one identity variable. To address the issue, multiple imputation (MI) was applied before any regression models were created for analysis.

According to Van Buuren (2018), “Multiple imputation is now accepted as the best general method to deal with incomplete data in many fields” (p.30). In the current study, 20 imputations were performed as recommended by Graham, Olchowski, and Gilreath (2007). The imputations were conducted using the Amelia package (R Core Team, 2019). An additional package, Zelig, was used to analyze the data after the imputations were complete (R Core Team, 2007). A total of 15,725 students were included in the analysis after imputations.

Dependent Variable

Students were asked to respond to the question, “To what extent do you disagree or agree with the following statements”. They were then presented with 17 STEM identity questions to rate on an anchored scale of 0 to 5, 0 being “No, not at all” and 5 being “Yes, very much”. Twelve of these statements were selected and grouped under the categories of Interest, Performance/Competency and Recognition (refer to *Table 3*). A confirmatory factor analysis (CFA) was conducted to confirm item alignment to the specific factors. Schumacker and Lomax (2010) posit that the recommended levels for fit indices include: chi-square $p < 0.05$; GFI $p > 0.90$; AGFI $p > 0.90$; RMSEA $p < 0.08$; NNFI $p > 0.90$; SRMR $p < 0.08$. The chi-squared value in this analysis is 1255.12; this is expected and is not being considered due to the substantial sample size. The other indices were within the recommended range: GFI is 0.98; AGFI is 0.96; RMSEA is 0.05; NNFI is 0.99; and SRMR is 0.01. Hence, the CFA supported the construct validity and item reliability of the STEM identity measures. All factors were statistically significant ($p<0.001$) and had factor loadings above 0.5 (refer to *Table 3*).

Table 3

Confirmatory Factor Analysis Results for STEM Identity Constructs

Latent Variable	Survey Item	Standardized Factor Loading (>0.40)	SE	Item reliability (r2) (>0.5)	Construct reliability (>0.70)	Average variance extracted (>0.50)
Interest	Topics in STEM excite my curiosity	0.92	0.01	0.85	0.96	0.86
	I enjoy learning about STEM	0.95	0.01	0.90		
	I like to know what is going on in STEM	0.89	0.01	0.79		
	I am interested in learning more about STEM	0.94	0.01	0.88		
Performance/ Competency	I feel confident in my ability to learn STEM	0.89	0.01	0.79	0.95	0.83
	I can do well on tests/exams in STEM	0.93	0.01	0.86		
	I understand concepts I have studied in STEM	0.93	0.01	0.86		
	I can overcome setbacks in learning STEM person	0.90	0.01	0.81		
Recognition	My family sees me as a STEM person	0.96	0.01	0.92	0.97	0.90
	My friends/classmates see me as a STEM person.	0.96	0.01	0.92		
	My classroom STEM teachers see me as a STEM person.	0.96	0.01	0.92		
	My out-of-school teachers see me as a STEM person	0.92	0.01	0.85		

After multiple imputations, the identity variables that are grouped into the three factors in *Table 3* were averaged into three proxy variables (Interest, Performance/Competency, Recognition). These were then averaged and grouped as one STEM identity proxy variable and was utilized as the dependent variable in the regression.

Since disciplinary identity and persistence have been found to be strongly related (Kane, 2012), a logistic regression was performed to assess predictive validity (as well as to address Research Question 1) in terms of how well the STEM identity proxy variable predicts STEM career intentions. STEM career intentions were determined by using responses to the question, "Which of these describes what you want(ed) to be in… beginning of first semester of college?" Students were then presented with numerous career options. 59.4% of the students selected that they wanted to be in a STEM career at the beginning of their first semester of college.

Blocked Regression Models

To respond to the research questions, a blocked regression analysis was completed with four different models (refer to *Figure 7*). In the first model, only controls were tested. These included average grade in middle school (English/Language Arts, Mathematics and Science), grade in last high school English course, high school mathematics courses taken (Pre-Calculus, Calculus, AP Calculus AB, AP Calculus BC), final grade in the most advanced mathematics course, total mathematics SAT scores, parent/guardian highest level of education, race (White, Black, Asian or Pacific Islander, American Indian or Alaskan Native, other), and gender. Variables in the regression models were retained or removed based on their statistical significance.

In the second model all significant control variables from Model 1 were retained and familial occupations were added to determine the effects on STEM identity before any other independent variables were considered. The implicit experience, familial occupations in STEM, was derived from students responding to a question that asked them to describe their family interest in STEM and to check if they had parents, siblings, or other relatives in STEM careers. The percentage of the respondents reporting family members with STEM-related careers were: 16.5% (female parent), 26.6% (male parent), 17.1% (siblings), and 28.6% (another relatives). Gender interactions related to familial occupations were also tested. Variables from the model were removed based on backwards elimination of nonsignificant interactions and main effects. To check if results were consistent with the backward elimination method, a stepwise method was used where variables were added one at a time. The results were identical. Model 2 addresses the second research question.

In the third model, all significant items in Model 2 were retained. Then, all explicit experiences were added. The alpha level was set low ($p \leq 0.01$) to avoid Type 1 error. The first of these was K-4 STEM experiences, where students responded to a question that asked them if they had specific hands-on, technology-based and nature-based experiences during their K-4 years. Some of these experiences included, *using tools to tinker with/take apart mechanical devices, reading non-fiction science* and *collecting things in nature*. Altogether, there were 24 experiences listed. Students responded if they had these experiences "often" or "sometimes" during their K-4 years. For the purpose of this study, "often" and "sometimes" were combined to indicate whether or not the students were involved in that experience.

The second explicit variable was encouragement, where students responded to the question, "Who encouraged you to select a STEM career path?" The current study focused on the responses of parents/guardians and elementary school teacher. The percentage of the respondents reporting encouragement with regards to STEM-related careers were: 17.5% (from female parent/guardian), 18.2% (from male parent/guardian), 4% (from elementary school teacher). The final explicit variable was a rating of science experiences in elementary grades (K-4). Students were presented with a 0 to 5 anchored scale, 0 being "Very memorable in a negative way", and 5 being "Very memorable in a positive way". Variables from the model were removed based on backwards elimination of nonsignificant interactions and main effects. To check if results were consistent with the backward elimination method, a stepwise method was used where variables were added one at a time. The results were identical. Model 3 addresses the third research question.

In the fourth model, all significant items from Model 3 were retained, and middle and high school interests were added. The alpha level was set low ($p \leq 0.01$) to avoid Type 1 error. In contrast to the other models, Model 4 included later interests in STEM in an effort to ascertain if significant early experiences remain significant. The results would reveal if early experiences continue to have an effect on college students' STEM identity despite the intervening factor of interest between middle and high school years. Thus, if they continue to be significant, it can be argued that they become contributors to identity capital. Model 4 addresses the fifth research question.

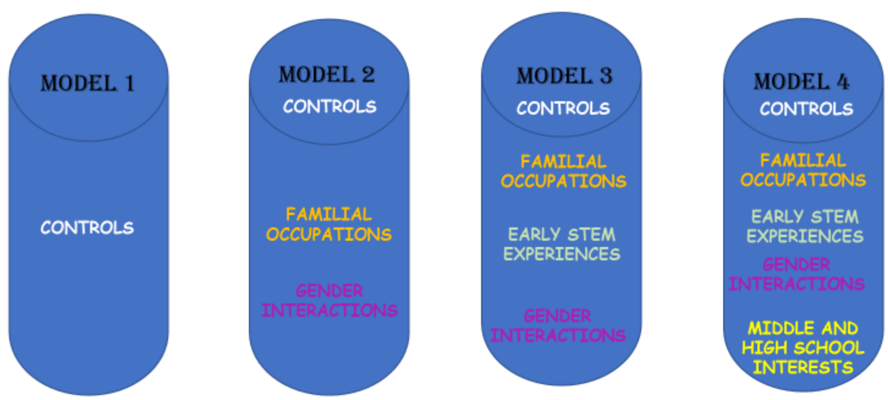

Figure 7. Regression Models

3.7. Results

The results from the logistic regression where the STEM identity proxy predicted STEM career intentions revealed that STEM identity was a significant predictor of STEM career intentions (B = 0.61, SE = 0.02, $p < 0.001$). The odds ratio was 1.84.

The results from the first regression model indicated that the significant controls were: gender, race (white), average grade in middle school for English/Language Arts, Mathematics, and Science, high school mathematics courses taken (Pre-Calculus, Calculus, AP Calculus AB, AP Calculus BC), final grade in the most advanced mathematics course, and total Mathematics SAT scores (refer to *Table 4*). The R^2 for the first regression model was 0.22. Non-significant variables include: grade in last high school English course, race (Black, Asian or Pacific Islander, American Indian or Alaskan Native, other), and parent/guardian highest level of education. The non-significant variables were removed from further analysis.

Table 4

Significant Controls (Model 1)

Parameters	**Estim**	**β**	**SE**	**Sig**
Intercept	1.04	0	0.09	***
Demographics and background controls				
Gender (0 = Non-female, 1 = Female)	-0.23	-0.08	0.02	***
Race (white)	-0.17	-0.05	0.02	***
Average grade in middle school English/Language Arts	-0.15	-0.08	0.02	***
Average grade in middle school Mathematics	0.05	0.03	0.02	**
Average grade in middle school Science	0.41	0.23	0.02	***
High School Pre-Calculus Course	0.15	0.05	0.03	***
High School Calculus Course	0.20	0.05	0.03	***
High School AP Calculus AB	0.32	0.08	0.03	***
High School AP Calculus BC	0.42	0.07	0.05	***
Most advanced Math course grade	0.12	0.08	0.01	***
Total Math SAT	0.06	0.15	0.004	***

** $p \leq 0.01$
*** $p \leq 0.001$

The second model included familial careers in STEM. The results indicate that male parent, female parent, sibling, and another relative were significant. No interactions with gender were found (refer to *Table 5*). The R^2 for the second regression model was 0.24.

Table 5

Significant Familial Occupations and Interactions (Model 2)

Parameters	**Estim**	**β**	**SE**	**Sig**
Intercept	1.04	0	0.09	***
Demographics and background controls				
Race, Academic Grade, Course Selection				Included
Gender (0 = Non-female, 1 = Female)	-0.25	-0.09	0.02	***
Familial Occupations In STEM				
Male parent career in STEM	0.11	0.03	0.03	***
Female parent career in STEM	0.13	0.03	0.03	***
Sibling career in STEM	0.08	0.02	0.03	***
Another relative career in STEM	0.37	0.12	0.03	***

*** $p \leq 0.001$

The third model included the significant factors from Model 2 and added early STEM experiences. In relation to early STEM experiences, 8 significant positive predictors and 2 significant negative predictors of STEM identity were identified (refer to *Table 6*). The R^2 for the third regression model was 0.31.

Table 6

Significant Familial Occupations, Early STEM Experiences and Interactions (Model 3)

Parameters	**Estim**	**β**	**SE**	**Sig**
Intercept	0.64	0	0.09	***
Demographics and background controls				
Race, Academic Grades, Course Selection				Included
Gender (0 = Non-female, 1 = Female)	-0.29	-0.10	0.03	***
Familial Occupations In STEM				
Another relative career in STEM	0.27	0.08	0.03	***
Early STEM experiences				
Observing/studying stars and other astronomical objects	0.09	0.10	0.03	**
Playing STEM computer/video games	0.12	0.04	0.03	***
Using STEM toys/kits	0.13	0.04	0.03	***
Watching STEM related TV programs or movies	0.20	0.07	0.03	***
Elementary school teacher encouragement in STEM	0.25	0.04	0.05	***
Female parent encouragement in STEM	0.32	0.08	0.05	***
Male parent encouragement in STEM	0.33	0.10	0.04	***
Rating of K-4 science experiences	0.18	0.14	0.01	***
Baking/cooking/kitchen chemistry	-0.14	-0.05	0.03	***
Writing about STEM, including creating online blogs/podcasts	-0.23	-0.07	0.04	***
Familial Occupations & Early STEM Experiences Interactions				
Interaction: Female parent encouragement in STEM x gender	0.25	0.05	0.06	***

** $p \leq 0.01$
***$p \leq 0.001$

One significant gender interaction was found. For female parent encouragement in STEM, the effect for female students was significantly larger than for non-female students (refer to *Figure 8*).

Figure 8. Gender Interaction - Female Parent Encouragement in STEM

In order to determine whether female students were more or less likely to report the significant positive/negative experiences in *Table 6*, logistic regressions were performed where gender predicted the likelihood of each experience. The odds ratios are summarized in *Table 7*.

Table 7

Odds Ratio of Non-female and Female students' Participation/Encouragement in Early STEM Experiences

	Estim	SE	Sig	Odds Ratio
Higher Participation/Encouragement - Female Students				
Baking/cooking/kitchen chemistry	0.41	0.03	***	1.50
Observing/studying stars and other astronomical objects	0.13	0.04	***	1.14
Female parent encouragement in STEM	0.22	0.05	***	1.24
Higher Participation – Non-female Students				
Watching STEM related TV programs or movies	-0.13	0.03	***	0.88
Writing about STEM, including creating online blogs/podcasts	-0.16	0.04	***	0.85
Using STEM toys/kits	-0.22	0.03	***	0.80
Playing STEM computer/video games	-0.37	0.03	***	0.70

*** $p \leq 0.001$

The fourth model included the significant factors from Model 3 and added controls for middle and high school STEM interests to determine the longevity of the effect of early STEM experiences in the face of intervening changes in attitudes between childhood and early college years. Seven early STEM experiences that were identified as significant positive predictors of STEM identity from the previous model were retained: *using STEM toys/kits*, *playing STEM computer/video games*, *watching STEM related TV programs or movies*, *elementary school teacher encouragement in STEM*, *male parent encouragement in STEM*, *female parent encouragement in STEM*, *rating of K-4 science experiences*. Two early STEM experiences that were identified as negative predictors of STEM identity from the previous model were retained: *writing about STEM, including creating online blogs/podcasts*, and *baking/cooking/kitchen chemistry*. In addition, having another relative in a STEM related occupation from previous models was retained (refer to *Table 8*). The R^2 for the fourth regression model was 0.50.

Table 8

Variables Retained after Controlling for Middle and High School Interests (Model 4)

Parameters	Estim	β	SE	Sig
Intercept	-0.11	0	0.08	ns
Demographics and background controls				
Race, Academic Grades, Course Selection				Included
Gender (0 = Non-female, 1 = Female)	-0.09	-0.03	0.02	**
Familial Occupations In STEM				
Another relative career in STEM	0.24	0.07	0.02	***
Early STEM experiences				
Using STEM toys/kits	0.07	0.02	0.02	**
Playing STEM computer/video games	0.07	0.02	0.03	***
Watching STEM related TV programs or movies	0.14	0.05	0.02	***
Elementary school teacher encouragement in STEM	0.18	0.05	0.05	***
Male parent encouragement in STEM	0.22	0.03	0.03	***
Female parent encouragement in STEM	0.20	0.05	0.04	***
Rating of K-4 science experiences	0.06	0.09	0.01	***
Writing about STEM, including creating online blogs/podcasts	-0.16	-0.05	0.03	***
Baking/Cooking/Kitchen Chemistry	-0.07	-0.02	0.02	**
Middle & High School Interests				
Middle school interest in Science	0.08	0.28	0.01	***
High school interest in Science	0.23	0.10	0.01	***
High school interest in Mathematics	0.10	0.14	0.01	***
High school interest in Engineering	0.11	0.08	0.01	***
High school interest in Computing	0.07	0.04	0.05	***
Familial Occupations & Early STEM Experiences Interactions				
Interaction: Female parent encouragement in STEM x gender	0.18	0.04	0.05	***

** $p \leq 0.01$
*** $p \leq 0.001$

3.8. Discussion

Research Question 1: STEM Identity and Career Intentions

In reference to the first research question, it is noted that STEM identity is a significant predictor of STEM career intentions based on the logistic regression that was performed. These results are bolstered by a substantial number of studies that report similar findings (Dou et al., 2019; Godwin et al., 2016; Hazari, et al., 2010; Wang & Degol, 2013). Students with a strong STEM identity believe that they can be successful in STEM fields and ultimately end up pursuing STEM careers. The odds ratio indicates that female students are 1.84 times more likely than non-female students to be affected by

STEM identity when considering STEM career intentions. This finding is bolstered by studies that indicate that female students that do pursue STEM related careers possess strong and positive STEM identity (Carolone & Johnson, 2007; Espinosa, 2011).

Research Question 2: Familial Occupations

Within the second model, all examined familial constructs (father, mother, sibling, and another relative) were significant. However, when early STEM experiences were added (Model 3), the only remaining significant variable related to familial occupations was having another relative in STEM. One reason that might explain why father and mother became non-significant is that parental encouragement was added as an early explicit experience. It is possible that parents that are employed in STEM also serve as significant encouragers in STEM. This encouragement may overshadow their employment in STEM, causing the latter to become non-significant. As far as the significance of another relative in STEM is concerned, one possible explanation is that immediate family members may become frequent participators in STEM activities with students, so they account for that variance whereas, other family members' careers may have a more implicit role (e.g. a role model rather than an active participant in students' regular STEM activities). Studies indicate that students can receive consistent support and guidance from extended family members that can contribute to their interest in pursuing similar career paths (Aryeetey, Doh, & Andoh, 2013; McLaughlin, Moutray, & Moore, 2010). Another reason that might explain the saliency of having another relative in STEM is that some students may have an absence of other STEM career role models, thus taking more extended relatives as implicit examples of what they can achieve.

Research Questions 3 & 4: Early STEM Experiences and Gender Interactions

The results of Model 3 revealed two early STEM experiences as negative predictors of STEM identity, and seven others as positive predictors. The first negative predictor, *baking/cooking/kitchen chemistry* (49.6% of dataset) could be viewed as a gendered activity traditionally taken up by women. Thus, it is antithetical to STEM, which is gendered as stereotypically masculine (Stout, Dasgupta, Hunsinger, & McManus, 2010). Thus, students may not consider these activities as being connected to STEM. The second negative predictor, *writing about STEM, including creating online blogs/podcasts/videos* (21.4% of dataset) may provide students with less agency and opportunity for identity development at such early developmental stages. Since most students in the K-4 schooling years are learning to read and write with relative fluency (National Reading Panel, 2000), using writing as means for developing STEM identity may be premature. Furthermore, studies indicate that seemingly traditional activities and methods, can negatively affect interest and limit cognitive growth (Marshall & Horton, 2011; Song & Kong, 2014). Thus, this activity may have been implemented in more rote or developmentally unsuitable ways (e.g., in terms of complexity) such that it was uninteresting, did not inspire confidence, and offered little opportunity of recognition for K-4 students.

Many of the positive significant predictors for females and non-females alike are associated with agency (students' own intentional choice to do something). Students often use *STEM toys/kits* (40.9% of dataset) in informal settings where they use their independent ability to perform these activities. Likewise, in relation to specific technology-based activities, agency comes into play as students choose to watch *STEM* *related TV programs or movies* (42.4% of dataset) and/or *play STEM computer/video games* (33.4% of dataset). These activities can be referred to as free-choice learning (Dhingra, 2006). Finally, students' involvement in observing or studying stars and other astronomical objects (32% of dataset) can be viewed as an extra-curricular activity (Bergstrom et al., 2016) that allows for autonomy. In addition, astronomy is viewed as an intriguing topic for students, increasing their enthusiasm and interest in science. As students' interest and confidence is nurtured, their STEM identity grows and is reinforced (Demski, 2009).

Another group of positive predictors deal with encouragement. The results indicate that both male and female parental encouragement are significant predictors of STEM identity. These results are supported by other studies confirming the saliency of home environment and parental encouragement in relation to identity development (Flowers, 2015; Warrington, 2013). Elementary school teacher support is also significant. Previous studies confirm the importance of teacher relationship in beginning years and how their support can lead to academic success (Alcott, 2017; Pianta & Stuhlman, 2004; Roorda, Koomen, Spilt, & Oort, 2011) and identity development (Raider-Roth, Albert, Bircann-Barkey, Gidseg, & Murray, 2008). The rating of students' K-4 science experiences was also a significant positive predictor. These results are bolstered by studies indicating that students' attitude (Archer et al., 2010) and early experiences (Akerson, Kaynak, & Erumit, 2019; Kane, 2016; Kim, 2018) in science are significantly related to their science identity.

The interaction effect of female parental encouragement in STEM with gender, showed a larger benefit for female students. Studies indicate that mothers are consistently emotionally involved in their children's education (Reay, 2000) and provide their daughters with encouragement and support (Rogers, Theule, Ryan, Adams, & Keating, 2009). The mother-daughter relationship and messages that daughters receive can be tied to their identity development (Thomas & King, 2007) and beliefs about their abilities in STEM (Bhanot & Jovanovic, 2009). Furthermore, "Women seem to use significant persons to help them define their selves more frequently than men" (Sjaastad 2012, p. 1624).

In examining the difference in prevalence of the significant experiences by gender, the odds ratio reveals that female students are 1.5 times more likely than non-female students to be involved in *baking/cooking/kitchen chemistry,* one of the two negative predictors of STEM identity. On the other hand, female students were less involved in four of the five positive predictors of STEM identity. These include: *playing STEM computer/video games*, 0.70 times less likely (or male students are 1.43 times more likely); *Using STEM toys/kits,* 0.80 times less likely (or male students are 1.25 times more likely); *Watching STEM related TV programs or movies,* 0.88 times less likely (or male students are 1.44 more likely). Consequently, if female students are less involved in activities that build STEM identity, and more involved in activities that negatively affect STEM identity, there is a decreased chance for identity growth and subsequent persistence in STEM. Therefore, it is imperative that female students be encouraged to participate in activities that can positively develop their STEM identity. In addition, activities that are typically seen as "feminine" and antithetical to having a STEM identity such as baking/cooking/kitchen chemistry, need to be promoted as ways in which STEM competence can be exemplified in order to counter stereotypical associations. There is one negative predictor, *writing about STEM, including creating online blogs/podcasts*, that is experienced more frequently by non-female (mostly male) than female students. Since male students at the K-4 level acknowledge their capabilities in technology (Beisser, 2005), this might explain their increased involvement. However, this activity also includes STEM writing which might be implemented in uninteresting ways for all students, especially male students who have less of an interest in reading and writing activities (Boltz, 2007; Unal, 2010). In addition, within the dataset only 21.5% of the students reported their involvement with *Writing about STEM, including creating online blogs/podcasts*, which is a much lower participation rate than other significant experiences. Therefore, the under-participation of students in the activity may exemplify disinterest and potential unsuitability for students at the K-4 level. These findings highlight a need for innovative approaches to bridge the gap between STEM and other core disciplinary areas such as reading and writing.

Many of the non-significant experiences that were eliminated in the third model, are related to nature-based experiences, such as *taking care/raising/training animals*, *observing/documenting animals*, *indoor/outdoor gardening*, and *observing clouds and weather patterns*. Although these activities might be valuable in increasing environmental awareness and encouraging an appreciation for the natural world, students may not perceive many of these activities as STEM related, limiting their contribution to the building and nurturing of STEM identity. For example, students might have participated with their families and communities in planting and tending gardens but might have been more focused on relationship building and cooking skills (Horning, Liden, & McMorris, 2017). Likewise, they might have taken care of or trained animals, but might have associated this activity with having a pet and the related bonding experience (Meadan & Jegatheesan, 2010; Melson, 2001).

Some of the non-significant experiences also conform to activities that might be considered less agentic and more structured. One example includes the reading of non-fiction material which could be tied to school activities (for example, reading textbooks and answering related questions) and thus provide students with less agency and opportunity for identity development. Studies indicate that activities that capitalize on traditional methods of learning can negatively affect interest and limit cognitive growth (Marshall & Horton, 2011; Song & Kong, 2014). Two other examples are *collecting/analyzing data for scientists* and *writing computer programs/games/apps*. These types of activities tend to be more structured activities at the K-4 level (Chiazzese, Fulantelli, Pipitone, & Taibi, 2017). Additionally, they may have been implemented in developmentally unsuitable (e.g., in terms of complexity) or uninteresting ways for K-4 students (Hava & Cakir, 2017).

Research Question 5: Early STEM experiences and STEM identity capital

Building on previous work developed by Côté (1996, 1997), the current study elaborates how assets (psychological and sociological) obtained early in life in the form of early experiences can remain stable over time and be viewed as STEM identity capital. The results confirm that select early STEM experiences from elementary school continue to have a positive effect on STEM identity in early college, after accounting for STEM interests during the middle and high school years. Seven of the eight positive predictors related to early STEM experiences from the previous model remained stable. Therefore, the K-4 experiences of *using STEM related toys/kits*, *watching STEM TV*, *playing STEM* *computer/video games*, as well as *encouragement from parents and elementary school teachers* can be viewed as contributing to STEM identity capital. One significant positive predictor from the previous model that was not retained is *observing stars and astronomical objects*. The loss of this experience as a source of STEM identity capital might be attributed to the experience being less formative as well as the subsequent absence of astronomy related activities in middle and high school further limiting the reinforcement of early astronomy experience (Krumenaker, 2009, 2010; Miranda, 2010).

Negative predictors, *baking/cooking/kitchen chemistry* and *writing about STEM, including creating online blogs/podcasts/videos* remained stable after controlling for middle and high school interests. Therefore, these two negative predictors negate the building and nurturing of STEM identity and serve as factors that carry over space and time to negatively affect STEM identity. In the case of *baking/cooking/kitchen chemistry*, if used within a classroom setting, students should be advised of the connection to STEM and stereotypical ideas related to this activity with respect to gender. If implemented at a K-4 level, the activity *writing about STEM, including creating online blogs/podcasts/videos* should be creatively connected to students' interests at the appropriate developmental level. The connection can be accomplished by adding agentic approaches and promoting a successful writing program across the curriculum. The gender interaction discussed in the previous model, mother's encouragement, also remained significant after controlling for middle and high school interests. This finding further supports the longevity of mother's encouragement, particularly for female students, in the face of intervening middle and high school experiences.

Most of the significant positive variables within the model exist as contributors to STEM identity capital (89%). They have greater impact than just influencing momentary shifts in identity. Unlike the variable *observing stars and astronomical objects* that served as a transient source to motivate STEM identity, the other variables had a more formative effect and carry implications for STEM identity reinforcement and maintenance in the future.

The differences in variances between the four blocked regression models are noteworthy. The first model included only controls, whereas the second model incorporated familial occupations. However, the difference in R^2 between the two models was 2%, reflecting minimal increase. Within the third model early STEM experiences were added and the R^2 between Models 2 and 3 increased by 7%. The nominal change between models 1 and 2 and the larger increase between models 2 and 3 highlights salient differences between implicit and explicit experiences. When students directly participate in activities (early STEM experiences) as opposed to indirect experiences (familial occupations), there is more of an effect on their STEM identity. Within the fourth model, middle and high school interests were added as controls, raising the R^2 between Models 3 and 4 by 19%. Even though the present study focused on early experiences, the importance of middle and high school interests emphasizes the salient role of these school years on students' STEM identity and career intentions. The significant change in R^2 might also relate to the fact that middle and high school years directly precede college enrollment, so experiences during those years are more proximal for students.

3.9. Limitations and Future Studies

Since surveys are self-reported, information may be subjected to social desirability bias where students report information that they perceive will be deemed favorable by others (Brenner & DeLamater, 2016). In addition, on the survey administered to first year college students, they were asked to reflect on their K-4 STEM experiences. For some students, unless these experiences were impactful, they might not have remembered or reported some of their lived experiences. However, when they do recall STEM experiences, the present study allows the opportunity to detect small effects that such experiences may (or may not) carry into the future. Another limitation, however, is that it cannot ascertain the nature of these experiences and how/why they may have impacted STEM identity development and maintenance. This is the purview of qualitative research. Since STEM identity capital has been utilized in a new context with reference to its ability to remain stable and transition over time and space, further studies will be conducted to explore its relationship to early STEM experiences. Furthermore, qualitative studies will be necessary to understand how/why specific lived experiences affect female students' STEM identity and career intentions.

Conclusion

The results from the current paper reveal that students' STEM identities are significantly impacted when they have other relatives employed in STEM occupations. Since many students may lack this form of capital, knowing about the effects of familial occupations becomes especially salient for teachers, counselors, and administrations. These school personnel can serve as positive role models and mentors providing support and encouragement for students.

Additionally, there are specific early STEM experiences whose effects remain stable over time and have positive or negative effects on STEM identity. These findings have important implications for structuring STEM teaching and learning. It can be used to shape and strengthen what a science teacher does in their classroom and can direct researchers to areas that need further study (such as how STEM toys/kits can be used to support the identity development of young women). Research on how early STEM experiences influence students' STEM identity can also be used by administrators implementing new programs in and outside of schools and to support the involvement of families and the community in the process. Within K-4 classrooms, the time spent on science is limited because greater focus is placed on literacy (Worth, Moriarty, & Winokur, 2004). More time concentrating on literacy, leaves less time for students to participate in science activities and for teachers to try to motivate/inspire students. "… we cannot expect students to develop a deep love for and understanding of science in middle or secondary grades, if they have not been given ample time to explore scientific concepts at the elementary level" (Wenner & Settlage, 2015, p. 512). Administrators have authority and resources to establish additional programs (before and after school), that they deem necessary to benefit students and influence their STEM identity and STEM identity capital into the future.

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CHAPTER 4

PHENOMENOLOGICAL CASE STUDIES ON HOW EXTENDED FAMILY OCCUPATIONS AND EARLY STEM EXPERIENCES CONTRIBUTE TO FEMALE STUDENTS' STEM IDENTITY/IDENTITY CAPTIAL

4.1 Abstract

The current qualitative study focused on the lived early STEM experiences of female undergraduate students who identified as having a STEM college major. Utilizing survey data and interviews collected from 16 female students enrolled in a large southeastern university, the current study provided first-hand accounts as to how specific lived STEM experiences might develop students' STEM identity and subsequent interest in STEM related fields. The analysis employed in the study allowed for emergence of significant themes, such as heightened emotions, influence of other people, and hands-on experience. Some students also identified specific early experiences as having continuous impact and being involved in these activities currently. These experiences exist as contributors of STEM identity capital that constantly influence identity. Suggestions are provided for administrators, teachers, and parents related to their involvement in specific STEM learning experiences and their influence as mentors.

Keywords: STEM identity, STEM capital, STEM identity capital, female students, career intentions

4.2. Introduction

Women are underrepresented in STEM fields and this has been a consistent and widely discussed issue within the United States (Morganson, Jones, & Major, 2010; Piatek-Jimenez, Cribbs, & Gill, 2018). According to a *Women in STEM* report, "… women are underrepresented both in STEM jobs and among those with undergraduate STEM degrees… The relatively few women who receive STEM degrees are concentrated in physical and life sciences, while men with STEM degrees are concentrated in engineering" (U.S. Department of Commerce, 2017, p. 11). With respect to the lack of women in the STEM workforce, researchers have focused on determining salient influences related to the persistence of women in STEM-related careers. Examining STEM identity development provides a compelling lens for understanding connections between early experiences and career intentions (Dou, Hazari, Dabney, Sonnert, & Sadler, 2019; Hazari, Sonnert, Sadler, & Shanahan, 2010). As a result, recent studies are becoming increasingly focused on identifying experiences that develop and nurture STEM identity in women. Some reported findings suggest that STEM role models (Hughes, Nzekwe, & Molyneaux, 2013), engaging in STEM activities (Riedinger & Taylor, 2016), and technology related experiences (Katz, 2011; Nation, Harlow, Arya, & Longtin, 2019; Vasbø, Silseth, & Erstad, 2014) can strengthen STEM identity in female students.

In a previous large-scale quantitative study, it was determined that specific early STEM experiences were positively related to college students' STEM identity, whereas other activities were negatively related to STEM identity (Chapter 3). The positive factors included: *using STEM toys/kits; watching STEM related TV programs or movies; playing STEM computer/video games; observing or studying stars and other astronomical objects;* and *encouragement from father, mother* and *elementary school teacher*, while the negative factors included: *baking/cooking/kitchen chemistry* and *writing about STEM, including creating online blogs/podcasts/videos.* Furthermore, female students were less likely to experience several of the positive activities and more likely to experience one of the two negative activities. The current study is a qualitative explanatory follow-up to the aforementioned quantitative study and provides depth of understanding and explicit details related to how familial occupations in STEM and early experiences might contribute to STEM identity and identity capital. In particular, the study takes a phenomenological case study approach where the cases are represented by the experiences previously found to be predictive of STEM identity in the quantitative work. Therefore, the current study will add to the extant literature by providing first-hand accounts taken from student interviews as to how specific lived STEM experiences might develop or weaken female students' STEM identity and subsequent interest or disinterest in STEM related fields. In addition, analysis of the interviews using a STEM identity capital lens, will provide evidence of how specific experiences might continue to impact female students' identity as they progress from elementary to college years.

4.3. Review of the Literature

Influences from Extended Relatives

Extended family members can serve as influences for students in a variety of ways. For example, they can provide informational support (Phillips, Christopher-Sisk, Gravino, 2001), and guidance (Crick, MacDonald, Perry & Poole, 2017). In a study completed by Bengtson (2001), he spoke of the importance of mutigenerational bonds and how they relate to providing support. More specific to career choice influences, Aryeetey, Doh, and Andoh (2013) discussed that extended family members, especially uncles and aunts, can influence students' choice of skills to pursue. Similarly, Pearson and Bieschke (2001) reported that some participants in his study indicated that extended family members were influential in their career development. In relation to extended family as career role models, Beck (2000) reported that nursing students indicated that they were influenced by family members such as mothers, fathers, sisters, grandparents, and uncles who were also healthcare professionals. Banks and Bailey (2010) referred to one of their participant's discussion regarding having multiple family members in nursing. There is a dearth of literature about extended family influence in other areas of STEM.

The important role that grandparents play in the lives of their grandchildren should not be overlooked. Bengtson, Harootyan, and Kronebusch (1994) documented grandparents providing economic resources, while King and Elder (1997) discussed their importance as role models. As it relates to the nursing profession, Banks and Bailey (2010), as well as Shattell, Moody, Hawkins, and Creasia (2001) indicated that students who chose nursing as a career had grandmothers who were or are still nurses.

Early Experiences

Early experiences in STEM for students can occur in a school setting where teachers often assume the role of facilitator, initiating steps for students to take responsibility for their own learning. In a study completed by Levitt (2002), teachers believed that science instruction and learning should be student-centered. In another study, Buldur (2017) reported a shift in methods of teaching from traditional to student-centered approaches subsequent to teacher involvement in an initiative for science education reform. Early STEM experiences originating from student-centered approaches have been known to increase interest in students (Jalil, Abu Sbeih, Boujettif, & Barakat, 2009; Jocz, Zhai, & Tan, 2014).

According to the National Research Council (2014), K-12 students in the United States, "… spend just 18.5 percent of their waking hours over the course of each year in school" (p. 1). Therefore, they have ample time and opportunities to engage in diverse activities *outside* of the classroom setting. As it relates to STEM and early experiences, numerous activities are available such as visits to science museums and/or parks with family members (Lee, 2012; Melber, 2006; Song et al., 2017) and intentional STEM interaction and engagements within the home environment, through the use of science activity packs (Strickler-Eppard, Czerniak, & Kaderavek, 2019) and everyday parental conversations and activities (Vahey, Vidiksis, & Adair, 2019). Additionally, afterschool programs allow students to interact with STEM outside of classroom hours. Young, Ortiz, and Young (2017) provided a meta-analysis and concluded that out-of-school time activities are positively related to STEM interest.

Early contact and consistent participation in activities within STEM-specific disciplines increase the chances for students to build their confidence and improve self-efficacy. Among elementary school students, Tran (2108) discussed the benefits of developing STEM and computer science (CS) skills early in life: “These experiences leverage opportunities to allow students to gain confidence, persistence, and develop self-efficacy in CS integrated concepts, ultimately, empowering students to reach their own potential for greatness” (p. 293). Similarly, Tugurian and Carrier (2017) explored 5th grade students’ environmental identity and concluded that this form of identity is unrecognized within a classroom context, potentially leading to a disconnect between the student interest and science.

Girls are exposed to stereotypical gendered views about STEM at a young age (Bian, Leslie, & Cimpian, 2017; Cvencek, Metzoff, & Greenwald, 2011; Master, Cheryan, Moscatelli, & Meltzoff, 2017; Steele, 2003). However, studies indicate that these views can be overcome through providing positive early experiences with STEM related activities. One such study was conducted by Master et al. (2017) with 6-year old students. They concluded that girls held to stereotypical views that boys were better than girls in computer programming and the stronger the stereotype held, the less interest and motivation held by the student. When placed in treatment and control groups, the girls that were involved in programming activities reported increased interest in technology. “These findings suggest that gender differences in children’s technology motivation are not set in stone; instead, they are malleable and open to influence from specific experiences” (p. 101). Similarly, girls in grades 1-5 reported increased self-efficacy through consistent computer use (Beisser, 2005). They also indicated that they were just as capable as boys. As it relates to science, Buck, Cook, Quigley, Prince, and Lucas (2014) present findings indicating that experiences such as a supportive lab teacher and inquiry-based activities improved elementary girls’ attitudes in science.

Early Encouragement

Parents influence their children during their early years, which can occur through discussions they have with their children as well as resources and activities they provide (Jacobs & Bleeker, 2004; Simpkins, Davis-Kean, & Eccles, 2005). Studies indicate that parental involvement and encouragement can lead to academic success. In a study completed by Jeynes (2005) among African American youth, he found that parental involvement was strongly associated to academic achievement. Similarly, a meta-analysis completed by Castro et al. (2015) reported strong associations to academic achievement "… when parents have high academic expectations for their children, develop and maintain communication with them about school activities and schoolwork, and promote the development of reading habits" (p. 41). Encouragement and involvement of parents assist with the development of students' identity. In a study completed by Sartor and Youniss (2002) connections were seen between adolescent identity and parental support. In addition, Jacobs and Eccles (2000) reported different ways that parents influence and encourage their children, such as being role models and providing specific learning experiences. The behaviors that they communicate can have lasting effects on children's values and self-efficacy.

Encouragement from Fathers

In viewing studies related to the impact of fathers and their guidance and involvement, Jeynes (2015) performed a meta-analysis including 66 studies and identified that fathers' involvement had positive effects for their children. Further studies indicated that fathers spend less time than mothers on at-school involvement, such as conferences with teachers, and involvement in parent-teacher associations, but spend equal time at home (Shumow & Miller, 2001). Another study among 55 fathers reported that fathers enjoy assuming the teacher role and spend more time than mothers assisting children with homework (Larson & Richards,1994). The time that fathers invest in their children through various methods is critical in the development of their identity and the building of identity capital (Pleck, 2007).

Several studies have been conducted to reflect the effects of fathers' support on their daughters' academic achievement and self-esteem. One such study was completed by Zia, Malik, and Ali (2015) among 321 adolescent girls. They reported a significant connection between the father-daughter relationship, and self-esteem and academic achievement. Likewise, Hazari, Tai, and Sadler (2007), described an increase in female students' physics performance if they reported that they had encouragement from their fathers. In another study conducted by Lee and Kushner (2008) among adolescent students from single-parent homes, they found that daughters from homes with a single father had higher academic achievement than other combination models of parent and child. Fathers' relationship to daughters is pivotal in their identity development and self-perceptions (Perkins, 2001) and social identity (Kazemeyan & Karimi, 2018).

Encouragement from Mothers

Mothers are often seen as caretakers and emotional supporters of their children. In a study by O'Brien (2007) among 25 mothers, she discussed how women categorize the care they invest in their children as it relates to education and their transition to secondary level schooling. She referred to mothers investing through listening and "… organizing their day to be available and on call when children might need their support; and attempting to do this in ways that were not intrusive or unacceptable to children" (p. 166). Griffith and Smith (2005) also detailed how mothers' routines are dictated by their children's schedule. Other studies indicate that mothers are more involved at school than fathers (Murray et al., 2006; Shumow & Miller, 2001). Irrespective of the increase of mothers in the work force, Bianchi (2000) reported that their time with children remained stable.

A large body of literature discussed the relationship between mothers and daughters. To begin with, mothers can serve as role models for their daughters. In a qualitative study by Warrington (2013) with 18 women, she highlighted mothers serving as role models through hard work and persistence. Mothers also provide career role modelling for their daughters and some studies reflect how mothers encourage and impact their daughters' identity and confidence in STEM. For example, Jacobs, Ahmad, and Sax (2017) referred to an increasing influence of mothers in engineering on their daughters' interest in engineering careers while Mireles-Rios and Romo (2010) report findings related to the effects of mothers' communication on girls' achievement and attitude in math.

Encouragement from Elementary School Teachers

Teachers can encourage elementary school students through their style of teaching. Within STEM, encouragement might be provided through allowing autonomy, such as creating situations where students in science can design their own questions (Flannagan & McMillan, 2009). Other times it might be related to their ability to facilitate discussions and stimulate creativity in children (Wood & Ashfield, 2008). However, these educators may implement programs based on their beliefs (Hermans, Tondeur, Van Braak, & Valcke, 2008) and teach information tied to their comfort level (Lee & Houseal, 2003).

Praise and encouragement from teachers can significantly impact students, giving them confidence and increasing their interest. Bohn, Roehrig, and Pressley (2004) indicated that effective teachers, "… praise students for specific accomplishments" (p. 270). They observed classrooms of more and less effective teachers and noted that more effective teachers praised students publicly, particularly the ones who were modelling appropriate behavior. Cornelius-White (2007) reported from a meta-analysis that person-teacher variables, such as empathy, and encouragement of learning, had an association with learner student outcomes. Similarly, Roorda, Koomen, Spilt, and Oort (2011) also conducted a meta-analysis and found that there were associations between affective teacher-student relationships and engagement. In addition to having effects on achievement and engagement, the teacher-student relationship and teaching methods can significantly affect students' identity and have a lasting impact on their lives (Franquiz & Salazar, 2004; Harrell-Levy & Kerpelman, 2010; Hazari, Brewe, Goertzen, & Hodapp, 2017, Kim & Slapac, 2015)

4.4. Theoretical Framework

The current study utilizes capital and identity lenses to view how students select and pursue STEM related careers. Capital, a concept developed by Pierre Bourdieu, refers to assets that individuals collect as they progress through life that create benefits for them in society (Bourdieu, 1986). These benefits might exist in the form of people they know (social capital), early experiences they have (cultural capital), money they acquire (economic capital), and degrees they earn (symbolic capital). Within the prior work framing the current study, a discipline-specific form of capital, STEM capital, was indicative of capital that was derived from having a relative employed in a STEM-related occupation and/or participating in early STEM related activities. Therefore, these two components will be viewed as STEM capital that exist to create advantages within a STEM community for individuals who possess them. The early experiences that students have might be viewed as implicit in nature, where they are not directly involved in the activity, such as having a family member in STEM. Other times, students may have explicit and direct experiences, such as completing an activity of watching STEM-related TV programs or movies.

The identity lens used in the current study is based on seminal work by Carlone and Johnson (2007) and expanded by Hazari et al. (2010). They presented an overarching framework that included the components: Competency/Performance, Recognition and Interest. The STEM identity lens utilized in the current study draws upon this framework and views these components from an overarching STEM perspective. In other words, how do female students feel about their ability to do STEM, how are they recognized by others with respect to STEM, and what part does interest play in their STEM progress.

In connecting the ideas related to STEM capital and STEM identity, another lens emerged and is referred to as, STEM identity capital. Identity capital work originated with Côté (1996) and his urgency to prepare young people to successfully integrate into society. “This strategic management involves developing, organizing, and executing a ‘portfolio’ of identity-based resources that are suitable to various institutional contexts… and more generally, are adaptable to a functional adulthood in a given society” (Côté, 2016, p. 4). Within the context of the present study, STEM identity is built through the accumulation of assets in early years as students interact with family members in STEM-related occupations and participate in STEM programs. As these assets assist with the development of STEM identity in early years, many can persist in the form of STEM-identity capital and over time as students transition into adulthood, they can enable students to successfully gain membership into a STEM community and negotiate their STEM identity in the face of new experiences.

4.5. Purpose

The purpose of the current study is to gain a deeper understanding into how and why specific familial occupations and early STEM experiences (previously found to have an effect) can contribute to STEM identity, identity capital, and career intentions. In addition, it is intended to empirically support and operationalize theoretical aspects of STEM identity capital that were introduced in the previous study (Chapter 3). In the previous work, there were glimpses into how STEM identity capital can continue to have an effect on identity after controlling for middle and high school experiences. The current study extends prior work in that it creates an opportunity to focus on the nature of these experiences through students’ reports on their early lived experiences. It is expected that analysis of these interview will uncover how female students’ participation in these activities might assist (or not assist) in maintaining their STEM identity beyond elementary school. Therefore, the following research questions are addressed:

1. What is the lived experience of having familial occupations in STEM (in this case, another relative) and how does this experience relate to female students' STEM identities and STEM career intentions?
2. What is the lived experience of participating in early STEM experiences and how does this experience relate to female students' STEM identities and STEM career intentions? (Early STEM experiences are focused on: Baking/cooking/kitchen chemistry, using STEM toys/kits, watching STEM-related TV programs or movies, playing STEM computer/video games, writing about STEM, observing or studying stars and other astronomical objects, encouragement from father, encouragement from mother, encouragement from elementary school teacher.)
3. How do these early experiences continue to affect female students' STEM identities years later?

4.6. Methods

The present study was conducted to better understand female students' early experiences that were previously found to be significant in predicting their STEM identities. These phenomena included specific *familial occupations* and *early STEM experiences*, as lived and narrated by female students majoring in STEM. Each phenomenon was viewed as a case, and students' early lived experiences were analyzed utilizing a phenomenological approach. As such, the research is framed as phenomenological case studies since it involves studying the lived experience of participants with respect to the bounded phenomenon being examined. Merriam (1998) describes a case study as being particularistic and focusing, "… on a particular situation, event, program, or phenomenon. The case itself is important for what it reveals about the phenomenon and for what is might represent" (p. 29). The current study utilized data (surveys and interviews) and analysis for each phenomenon as reported by the participants. The intent of phenomenology is to look for the essence and common meanings of lived experiences (Creswell, Hanson, Clark, & Morales, 2007), therefore the interviews that were conducted and surveys that were administered were examined in search of meaning and commonalities related to the phenomenon.

An initial step in the phenomenological approach is to identify individuals who have *lived experiences* of the phenomenon (Creswell, 2013). Finding these individuals was accomplished by creating a shortened version of the initial survey from a previous quantitative study where significant variables were retained. One example of a significant variable relates to elementary teacher encouragement and students were asked the question: "If you plan on pursuing a STEM career, did your elementary school teacher encourage you to select a STEM career path?" Demographic information (e.g. gender and race), as well as academic controls (e.g. average grade in middle school and ACT/SAT scores) were retained along with middle and high school interests in STEM. Identity constructs were also kept where students were asked to rate to what extent they disagreed or agreed with statements on an anchored scale of 0 to 5, 0 being "No, not at all" and 5 being "Yes very much". One example on an identity construct was: "I feel confident in my ability to learn STEM". The purpose of these questions and interview selection was to further explain the results from the previous quantitative studies.

The abbreviated version of the survey was administered to students in introductory science classes at a large university within the United States. If students were interested in being interviewed about their experiences, they provided their names and email addresses at the end of the survey. For the students that indicated that they were interested in being interviewed, specific criteria for their selection as participants for the study were utilized. These included if the student was female, intended on pursuing a STEM related career, had a high rating of STEM identity (at least a 4 on a scale of 0-5), and had specific K-4 STEM experiences.

After the survey was administered to introductory sciences classes, a total of 36 students were identified as meeting the preexisting criteria. Personalized emails were sent to these students, which described the study and provided contact information along with the Institutional Review Board (IRB) approval number.

From the total group, 16 students responded and were interviewed. These students were provided a consent form and all questions and concerns related to the study were addressed prior to the interview. Nine of the interviews were completed over the phone and were audio recorded via the *Rev Call Recorder* application. Seven interviews were completed in person and the *Voice Recorder* application was utilized for audio recording. The interviews lasted between 25-45 minutes and students were asked to describe their lived experiences. Sample questions included: You mentioned that you were involved in *playing STEM toys/kits* during your K-4 years. Can you share this experience? How did this experience affect your interest in STEM if at all? Of all the things that happened to you in childhood, why do you think you remember this particular experience? Follow-up questions were asked by the interviewer to provide clarification and gather further details (Rubin & Rubin, 2012). The 16 interviews were transcribed for analysis. The racial groups that participants identified with were: White (69%); Black (19%), and Multi-racial (12%). Additionally, 31% students identified as Hispanic. Lastly, 81% indicated they were in their first or second year of college, and 19% identified as other years.

Trustworthiness

The primary researcher maintained a research journal in which she recorded her reflections and progress with the project. She kept the journal to be transparent in the process of completing the study and to self-reflect on her own progress and research methods. In addition, Merriam (2002) discussed using detailed description in reporting. She referred to being, "… richly descriptive. Words and pictures rather than numbers are used to convey what the researcher has learned about a phenomenon" (p. 5). In the current study detailed summaries are provided, along with quotes when reporting the data.

As consistent with phenomenological research, the interviews were audio taped and transcribed verbatim (Larsson & Holmström, 2007). These transcripts were sent to the participants to check for accuracy and to edit their responses. Four students made edits and eight confirmed that the transcripts were accurate.

Analysis

Analysis of the data was guided by the phenomenological approach. To begin with, the research team bracketed any preconceived ideas so that the data could be viewed from a fresh perspective (Creswell et al., 2007). The process involved the team going through preliminary questions that were created for the participants and answering them. Assumptions and biases were acknowledged based on personal experiences related to the phenomenon. These were written down, examined, and placed under the label of, "earlier personal conceptions". By completing the process, the team was able to begin analyzing the data having identified and confronted personal biases and preconceptions. For example, the primary researcher was involved in the early experience of *observing or studying stars and other astronomical objects*. Her lived experience with the phenomenon included encounters that were very specific to her including preconceived ideas related to girls in astronomy. She was able to identify her experience as personal and acknowledge that the interviewees might have had experiences and conceptions that are completely different from her.

An emergent strategy was utilized to enable findings to surface from within the data (Moustakas, 1994). First, the transcripts were read in entirety so that initial codes could be created. These initial codes were handwritten, and sections of the text were highlighted. QDA Miner software was used to further assist with a coding scheme and theme clustering. Thematic units continued to emerge from the data during analysis. These themes were coded while the corresponding text was highlight and organized into a tree structure. Textual and structural descriptions were written which pointed to commonalities and the essence of the phenomenon (Creswell, 2013; Moustakas, 1994). As described before, these themes were not predetermined, in terms of nature of the individual experiences. However, there were a priori codes for STEM identity and STEM identity capital.

4.7. Results

As previously stated, each phenomenon was viewed as a case. *Table 9* provides a summary of each participant's self-reported involvement with the specific phenomenon. *Table 10* provides an overall summary of emerging themes and the number of participants reporting each lived early STEM experience. Each case and the associated emerging themes, as well as exemplars from the data, will be described in the next few sections. These emerging themes within each case are listed in the order of reported frequency (most mentioned to least mentioned).

Table 9

Early Experiences Reported by Individual Female Students

Name	Another Relative in STEM	STEM Toys/ Kits	STEM TV Programs or Movies	STEM Computer/ Video Games	Stars/ Astro-nomical Objects	Baking/ Cooking/ Kitchen Chemistry	Writing About STEM	Father Enc	Mother Enc	Elemen-tary School Teacher Enc
Beth		✓		✓					✓	✓
Bianca		✓	✓	✓	✓	✓		✓	✓	
Dina				✓	✓	✓			✓	
Liz	✓	✓					✓	✓	✓	
Susan	✓	✓	✓			✓				✓
Evie	✓		✓	✓	✓	✓		✓	✓	
Olivia	✓									✓
Jen	✓		✓			✓		✓	✓	✓
Trista			✓	✓				✓	✓	
Chloe	✓	✓	✓	✓				✓		
Wanda	✓	✓						✓		✓
Rachel			✓	✓	✓	✓		✓	✓	
Grace			✓						✓	✓
Haley	✓		✓	✓	✓			✓	✓	
Pat					✓		✓		✓	
Iris		✓	✓		✓				✓	
Totals	**8**	**7**	**10**	**8**	**7**	**6**	**2**	**9**	**12**	**6**

Table 10

Emerging Themes and Number of Participants Reporting Each Lived Early STEM Experience

Experiences	Total Number of Students Engaging in Activity (%)	Themes (Number of Students)
Another Relative in STEM	8 (50%)	1. Quorum (7) 2. Mentorship (3)
Using STEM toys/kits (e.g., building/construction sets, circuit boards, model rockets, science kits)	7 (44%)	1. Hands-on Experience (7) 2. Heightened Emotions (7) 3. Influence of Other People (4) 4. Continuous Engagement (3)
Watching STEM-related TV programs or movies (documentaries, dramas, sci-fi)	10 (63%)	1. Heightened Emotions (9) 2. Continuous Engagement (7) 3. Cognitive Engagement (6) 4. Future Connections (5) 5. Influence of Other People (4)
Playing STEM computer/video games	8 (50 %)	1. Heightened Emotions (7) 2. Influence of Other People (5) 3. Reward (3) 4. Agency (3) 5. Cognitive Engagement (3) 6. Continuous Engagement (3)
Observing or studying stars and other astronomical objects	7 (44%)	1. Heightened Emotions (4) 2. Influence of Other People (4) 3. Hands-on Experience (3)
Baking/cooking/kitchen chemistry	6 (38%)	1. Cooking with mother (5) 2. Hands-on Experience (5) 3. Continuous Engagement (4)
Writing about STEM, including creating online blogs/podcasts/videos	2 (13%)	1. School Assignment (2)
Encouragement from father	9 (56%)	1. Verbal Praise/Encouragement (9) 2. Homework Assistance (6) 3. STEM Resources (6) 4. Continuous Engagement (4) 5. STEM in Daily Life (3)
Encouragement from mother	12 (75%)	1. STEM Resources (9) 2. Verbal Praise/Encouragement (8) 3. STEM career role model (6) 4. Continuous Engagement (6) 5. Homework Assistance (4) 6. STEM Learning/Career Conversations (4)
Encouragement from elementary school teacher	6 (38%)	1. Continuous Engagement (4) 2. Verbal Praise/Encouragement (3) 3. Engaging Teaching Style (3) 4. Participation in STEM Activities (2)

Other Relatives Employed in STEM Fields

Eight students (50%) indicated that they had another relative in STEM. From the analysis, the following themes emerged: Quorum and Mentorship.

Quorum.

Of the students that reported that they had a relative (beyond parents and siblings) in a STEM career, seven students mentioned that they had more than one relative working in a STEM field. For example, Haley reported that she had two cousins, Jen shared that she had an aunt and cousins, and Liz reported she had a stepmom and cousins in STEM fields. Two participants (Wanda and Evie) referred to having several other extended family members employed in STEM-related fields. Wanda referred to their influence by saying, “You kind of want to be like your family members. You look up to your family members… I kind of based myself on what I think would be best to suit my family, I guess.” Four participants also mentioned that at least one of their other relatives working in a STEM career lived overseas. It is important to note that while the students were recruited on the criterion of reporting on the survey that “STEM is involved in another relative’s career”, which is phrased in the singular, almost all of the participants had multiple relatives in STEM careers.

Mentorship.

Three of the participants referred to their other relatives serving as mentors through talking about STEM and providing resources and help as well as being subjects for observation for the students. They mentioned that they observed their other relative studying in areas related to STEM and reported that they were able to talk to these relatives about their careers. Susan indicated that her uncle told her stories related to his career and her cousin, who was still preparing for her career, shared struggles she was going through. Chloe discussed that her aunt, who was studying physical therapy, doing exercises and stretches with her and talking about her career. She indicated, “My aunt had a big influence on me with being a physical therapist… I knew what it was, at a young age, I was already exposed to that option.” Finally, Susan and Olivia indicated that their other relatives provided resources for them. Susan said, “He’s always sending me books, and links, and stuff, and show, documentaries to watch,” while Olivia talked about her cousin helping her with applications for STEM related degrees.

Two students referred to their other relatives providing verbal encouragement related to their STEM career. For example, Olivia referred to her second cousin strongly encouraging her to study within a STEM related field. Chloe referred to her family, including her aunt, always telling her to pursue her interest and that she was, “… capable of achieving anything no matter how difficult it was”.

Early STEM Experiences

Using STEM toys/kits.

Seven students (44% of participants) reported using STEM toys/kits during their K-4 years. Four themes emerged from the analysis: hands-on experience; heightened emotions; influence of other people; and continuous engagement.

Hands-on experience.

All students that reported the experience referred to the hands-on nature of STEM toys/kits. Some examples include, Bianca’s discussion on her encounters with a surgery kit where she had to place the correct organs of the body into a figure. She also mentioned having a mannequin that had the muscles and body parts that she would take apart. Beth talked about working with wires and batteries and setting up a circuit that had a light bulb. Wanda indicated that she, "… had one of those little science kits and you can create like different slimes and things like that." She referred to adding and mixing material together while observing the different texture and color changes. Chloe referred to constructing a volcano with the help of her father.

Heightened emotions.

All the students that reported participating in the experience, also referred to having heightened emotions while working with STEM toys/kits. For example, Liz referred to being enthusiastic about participating in rocket experiments that were conducted at school. Susan reported using building blocks and Legos and her excitement in engaging with this activity. Bianca referred to her experience with using a surgery kit and a mannequin as "cool" and indicated that through her participation with STEM toys she had an increased interest. "… it made me like STEM more because I'm already interested in STEM. So, by having those it just sparked my interest even more."

Influence of other people.

In reference to the use of STEM toys/kits, four students reported the influence of other people. Bianca indicated that her parents bought her a surgery kit and a mannequin and interacted with her as she played with them. Chloe referred to her father being around and helping her as she participated in the experience of designing a volcano saying, "He was the one who drilled the mesh to the board and helped me do everything and taught me why volcanoes erupt with the chemical we used." Liz indicated that the teacher provided guidance and demonstrated rocket experiments and other labs, while Beth referred to the teacher encouraging and supporting the class as they constructed circuit boards in school.

Continuous engagement.

Three students mentioned the early and continued impact of STEM toys/kits. Beth indicated that she continued to pursue her interest in how things work and that participating in creating a circuit was an early experience that allowed her to see how connections were made to a lightbulb. She mentioned that the memory stuck with her for that reason. Bianca shared that she used her surgery kit and put the parts of the mannequin together frequently. She reported that the experience gave her "… a better understanding of anatomies." As a result, in her high school years she gravitated to the same types of toys in her anatomy classes for test review. Similarly, Liz spoke about being exposed to blocks and rocket experiments in class and how interesting these activities were for her in the moment. She referred to participating in similar activities later in life.

> In middle school, I had to build a bridge out of ... toothpicks or wooden popsicle sticks. Sometimes, I think about my earlier experiences and the fun times I had with the activities that made me begin learning things that I am doing now.

As such, early experiences with STEM toys/kits were reinforced for these students through related experiences as time progressed.

Watching STEM-related TV programs or movies.

Ten students (63% of participants) responded that they participated in watching STEM-related TV programs or movies during their K-4 years. From the analysis, five themes emerged: heightened emotions; continuous engagement; cognitive engagement; future connections; influence of other people.

Heightened emotions.

Nine students referred specifically to being excited about watching STEM TV and movies. For example, Trista described watching a program at school and being excited enough to continue watching others at home. Rachel reported that "The Magic School Bus" made her so excited about space and made her think of future space possibilities. Grace indicated, "… after watching those shows specifically and being exposed to that, that's when I started getting into the mindset of, I like biology," and Jen reported that when she watched documentaries, she was interested in digging deeper and finding out "… the meaning behind things instead just looking at the superficial." She mentioned that it inspired her to complete research to find out specific details.

Continuous engagement.

Seven students mentioned watching STEM TV/videos early in life and the impact the experience had on them watching STEM TV programs/videos later. Grace said,

> I was always actively watching at some point throughout my life all those documentaries and those shows… it never went away. I never lost interest in that… it evolved into more easier [sic], accessible media through YouTube for

example… I'm always searching up stuff like that specifically right now present day.

Rachel and Haley indicated that they both still watch STEM related shows while Trista talked about watching STEM related programs and movies with the same childlike wonder. Susan explained that she still searches for documentaries and shows on Netflix to get accurate descriptions and a better understanding of STEM-related material making her "… more inclined to continue pursuing STEM".

Cognitive engagement.

In relation to watching STEM-related TV programs or movies, six students reported that it enabled them to have a deeper understanding of science concepts. Bianca mentioned that she was very interested in Forensic Files and that she gained knowledge from watching these shows, "They always go in depth with anatomy… they'll show you the forensic aspect of it." Susan and Rachel both shared that in their STEM classes they would watch videos about various topics to gain insight into concepts they were learning in class. Jen indicated that watching documentaries helped her see hidden meanings into topics. "They go into the deep meaning of things instead of just looking at what the eyes can see… the cell function and stuff like that." Trista referred to watching Bill Nye to get answers to science questions and Grace described how she learned to take care of animals in an emergency as a result of watching STEM-related programs.

Future connections.

Five students referred to how they saw future career connections through watching STEM-related TV programs or movies. For example, Haley discussed watching many science videos and realizing that it might be related to what she would do in the future. Iris talked about watching the Discovery Channel and making connections to getting into the health professional field. Grace mentioned, “But if it hadn’t been for that beginning exposure of those shows, I probably would not have discovered it [biology interest] as easy.” Evie took it a step further and said that when watching STEM related TV programs and movies, she thought about the future.

> It showed me the possibilities of the future, even though it might not necessarily be realistic in my lifetime… It showed me like, ‘Hey there’s nothing stopping me for being the one that wants to do this or have a foundation that other people of other generations could build on’.

For these students, watching STEM programs helped them envision the future of STEM and their place in in.

Influence of other people.

Four students referred to being acknowledged by other people while watching STEM-related TV programs or movies. Bianca indicated that when she watched Forensic files her sister would tell her that she should become a forensic scientist since she liked it so much. Susan reported that her parents and some friends would explicitly recognize her habit of watching STEM programs. Jen talked about her father consistently watching documentaries, and how he presented opportunities for her to join him. Haley reported that her mother said that since she was so interested in science, she, "…could probably do something out of it."

Playing STEM computer/video games.

Eight students (50% of participants) indicated that they were involved in playing STEM computer/video games during their K-4 years. From the analysis, six major themes emerged: heightened emotions; influence of other people; reward; agency; cognitive engagement; continuous engagement.

Heightened emotions.

Seven students referred to playing STEM computer/video games as enjoyable. Beth mentioned that the online mathematics website 'Cool Math' was interesting and fun, while Haley referred to mixing chemicals online and having fun with it. Trista discussed her encounters with playing "Spore" and excitedly reported, "Are you kidding me! Giving that as a tool to like an adolescent, that's insane. So cool." Dina shared that she liked playing an astronaut game and how it sparked her interest. Similarly, Bianca talked about her increased interest in STEM as a result of playing science computer games. She said, "It did make me more interested just because it kept sparking my interest as I'm playing the games… I could experience and see how it is and how the operations work."

Influence of other people.

Five students mentioned other influential sources that were involved while they were playing computer games. Beth indicated that her teacher and the other students noticed and pointed out that she was playing harder computer games than what they were playing and saw that she was really interested in STEM related games. Bianca talked about her teacher also noticing the games she played, which were related to science and medicine and indicating that she should probably become a doctor when she got older. Some familial influences were also described. Chloe mentioned that her mother observed her playing surgery related games and she appreciated that Chloe was interested and enjoyed these games. Dina reported that her father introduced her to an astronaut game and she said he was, "… always focused on trying to get me to think and do comprehensive and basic strategies." Evie referred to her cousins inspiring her to become involved in playing STEM related video games.

Reward.

For three of these female students, STEM computer games offered opportunities for positive moments during the school day. Rachel referred to being able to use math and other computer games as a reward when they had finished their assignments early, while Haley and Bianca mentioned playing these games during free time on classroom computers.

Agency.

In the area of agency, three students reported the independent nature of playing and selecting STEM computer games. Trista enthusiastically described agency in playing a Pokemon game and referred to it as "… having amazing priority on science and discovery. She talked about being in a "… fantasy world of Pokemon scientists" and the individualized approach to finding characters and role playing. She indicated that they games, "… give you the agency and this assignment of going out into the world and discover as many of these weird creatures as you possibly can and report back so that I can fulfil my research." Bianca and Chloe referred to agency in game selection. Bianca mentioned playing mathematics and science focused games every week in school. Along with her classmates, she was given the opportunity to select any game she wanted to play. Chloe reported having games to choose from, such as 'cool math' online games and a surgeon game, while waiting for her mother after school.

Cognitive engagement.

Three students communicated that they understood STEM through playing STEM computer/video games. Two of them referred specifically to being interested in the medical field and learning about how to do surgeries through games. Chloe said, "I actually learned like scalpel [sic] and how you have to draw the lines and where you're making the incision. I learned all of that through the game". Similarly, Bianca said, "There was one game I would play, it's like you're doing surgeries on a cartoon online… I could experience or see how it is and how the operations work." Trista discussed exploring and thinking about developing organisms when playing a "Spore" computer game.

Continuous engagement.

Three students indicated that playing STEM computer/video games during their K-4 years had effects on later years. Chloe referred to still remembering playing those games and how they set the groundwork for her understanding of concepts. Likewise, Rachel referred to the activity, in addition to others, as setting up the "… pavement to be who I am today.” Trista indicated that she still plays STEM computer/video games and referred to her positive memories of them, saying, “I remember them vividly because I have such strong personal and positive memories with them, and also because they stand up to the test of time and I can still decide to play them if I want.”

Observing or studying Stars and other astronomical objects.

Seven students (44%) referred to participating in observing or studying stars and other astronomical objects during their K-4 years. From the analysis, three major themes emerged: heightened emotion; influence of other people; hands-on experience.

Heightened emotions.

Four students discussed their fascination with observing and studying stars and other astronomical objects. Haley said, “It was kind of fascinating to see those stars since they're so far away. They're practically dead, but they're still here!” Similarly, Pat talked about wanting to know, “… where stars come from, and why they’re there” and being “…super obsessed with the stars” after visiting planetariums. Rachel shared that she, “… loved to lay outside and just look at the stars and try to find the patterns”. Bianca also reported that she initially liked astronomy, but after using her telescope and looking at the stars, her interest sparked even more regarding learning what was out there.

Influence of other people.

Four of the students referred to completing observing and studying stars and other astronautical objects with a parent. Iris talked about observing with her mother, while the other three reported that they had the experience with their fathers. Dina discussed looking at the stars with her father, and it being a "bonding thing" for the whole family. Bianca reported watching a lunar eclipse with her father through the telescope that he purchased for her, while Pat indicated, "… my dad taught me some constellations… and then on my own he would take me to the planetariums and there you could see it."

Hands-on experience.

Three students discussed using telescopes in their observation of stars and other astronomical objects. Bianca referred to her father buying her a telescope because of her love for astronomy. She shared being able to look in more detail at the moon and a lunar eclipse. Dina mentioned that she also had a telescope and they would go outside and watch the stars and moon. Evie talked about using the large telescope in the science museum during her visits there.

Baking/Cooking/Kitchen Chemistry.

Within the study six students (38% of participants) indicated that they participated in baking/cooking/kitchen chemistry during their K-4 years. Three themes emerged from the data specific to their lived experiences: cooking with mother; hands-on experience; and continuous engagement.

Cooking with mother.

Five female students indicated that they cooked with their mother and of this group, three of them referred to it as being a bonding experience. For example, Dina said, "But I think for the most part, it was just something fun I would do with my mom." Similarly, Susan said, "I feel that's part of a relationship with my mom." Rachel indicated that her mom was a very adventurous and spontaneous cook and shared some of her experiences of her mom making, "… everything out of nothing." As a result of cooking with her mom, Rachel developed a love for cooking. She reported, "It's bonding with mom and it tasted delicious, and I just enjoyed doing it."

Hands-on experience.

In relation to baking/cooking/kitchen chemistry, five students referred to it as a hands-on experience. Some examples were, Jen discussed always liking to bake and referred to coming up with original and unique recipes. She said, "I try with different baking powder, different baking soda, … different amount of flour and I would come up with recipes ever since I was a young child." Rachel shared her experience of loving to cook since childhood and participating in cooking and baking experiences with her mom. Dina reported developing a passion for cooking and baking. She said, "I would go by myself, heat up the oven and make myself cookies or make the house cookies."

Continuous engagement.

Four students referred to still engaging in cooking and baking. Jen talked about still baking whenever she could and coming up with unique recipes. She said, "Just the other day, I made cookies. I made up a recipe there and today I'm going to make a pumpkin pie." Evie referred to her love for cooking now and adding lots of seasoning for taste. Rachel shared, "I cook about 90% of my meals. I don't usually eat out. So, I think it's just grown on me now." Susan also indicated that she still does a lot of cooking and baking at home.

All the students who indicated that they were involved in the experience reported that they did not see any relationship to STEM. For example, Bianca said, “I think it’s unrelated”. Evie responded that she did not see a STEM connection, but rather, “… this is what my mom wants me to do, so I didn’t really consider it.” The students did not feel like engaging in baking/cooking/kitchen chemistry increased their interest in STEM or that it allowed them to be recognized as STEM people. Susan said, “I don’t think that that played a role in my interest in STEM. I feel like, to me, I don’t deem it to be related.”

Writing about STEM (online blogs/podcasts/videos)

Two students (13%) indicated that they participated in writing about STEM and two others mentioned their participation during middle and high school years. One theme emerged: school assignment.

School Assignment.

Two students referred to the activity as being school related. Pat indicated that they were given the chance to create a research project on plants or they could pick something else. She mentioned, “She [the teacher] literally just told us oh, pick anything and I’m like oh I’m going to test balloons I guess.” She mentioned testing the experiment related to how water affected a balloon when it was dropped and writing up the project. The other student, Liz, indicated that she completed brochures related to earth science and animals. Generally, it was related to “… the anatomy of an animal or maybe a volcano”, and sometimes short PowerPoints were included with the assignment. These brochures were usually printed out and they had to present them in class.

Despite the fact that the quantitative study item from which the current qualitative work was derived included the example of writing blogs/podcasts, there was no reference by the participants related to larger technological connections when writing about STEM. When Liz was asked if she completed any of these, she indicated, “It was never online.” Likewise, Pat just mentioned testing her project and writing it up.

Encouragement from father.

Although mentorship was discussed as a whole when reporting the effects of having other relatives in STEM due to the idiosyncratic nature of how different relatives influenced students, the various components of mentorship, such as providing STEM resources and homework assistance, are discussed individually for parents since multiple respondents reported these ways of experiencing mentorship from parents. Additionally, of seven female students that indicated that they had a father in a STEM field, all of them reported that their fathers encouraged them to select a STEM career path. Likewise, of seven students that mentioned that they had a female parent employed in STEM, all of them also reported that their mothers encouraged them to select a STEM career path.

Nine female students (56% of participants) indicated that they had a male parent who encouraged them to pursue a STEM related career. Five major themes emerged from the analysis: verbal praise/encouragement; homework assistance; STEM resources; continuous engagement; and STEM in daily life.

Verbal praise/encouragement.

Nine students indicated that they specifically received verbal praise and encouragement from their fathers. For example, Liz said,

> … he'll motivate me by saying that I should stick to what I have, and he's really proud of what I've done so far and that he can really see that I'm passionate about this career path and to keep going.

Similarly, Wanda indicated that, "He's always been kind of telling me, 'Oh you should go into something like this, something in STEM because you're really good at that'." Bianca and Trista both reported that their fathers gave them specific STEM career advice and encouragement. For example, Trista said her father suggested that she pursue engineering and mentioned he encouraged her "… to take on things that were challenging… so he played a huge part in getting me through to where I am. And it's something that is so huge it can't go unacknowledged."

Homework assistance.

Six students talked about their fathers encouraging them through helping with homework in STEM related classes. For example, Rachel mentioned, "From day one, before I knew I liked math, he was the one who was helping with my math homework from kindergarten and on… it made me realize that I really enjoyed it." Evie even referred to her father as still being a current source of math support. "Even to this day, I still call my dad and be like, 'Hey I'm doing bad in Calculus. Can you help me out'?"

STEM resources.

Six students who reported that their male parent encouraged them indicated that they received specific resources from their father. For Bianca and Rachel, they received tangible resources such as kits, telescopes and books. On the other hand, Evie talked about how her father provided the opportunity for her to work with computer programs, took her to museums, and tried to find any programs that would help her. Bianca and Wanda also shared that their fathers took the *time* to teach them new math related concepts so they would be ahead of the other students. Wanda said, "My dad taught me some things before I actually learned them and then when I got there everything was really easy. So, yeah that kind of encouraged me." Bianca shared, "He's going to start like incorporating it slowly for me so I could learn ahead of time."

Continuous engagement.

Although many of the students implied their father's support later in life, four students explicitly discussed their father's continuous engagement with them while growing up. For example, Bianca indicated that as she grew older, her dad would spend time talking to her about getting into medical school and completing it. Trista mentioned that as the years went by, her dad was still the one that would fix electronics around the house. Chloe talked about her dad fixing things around the house when she was younger, and still influencing her currently, stating "When I just went [to visit] in the summer, he was showing me how to put the sink together and the pipes and we actually cut the baseboards with his own machine and we were putting it together." Evie mentioned her dad providing homework assistance when she was a child, and how she still seeks his assistance in math for her college classes.

STEM in daily life.

Three students communicated how their fathers provided encouragement by incorporating portions of their STEM career into homelife. Evie's father was in technology as a career and she indicated,

> If the computer was acting slow or anything like that, it's seeing him able to fix it, not only just type, but also open up the computer and check and everything like that is what I was like, 'Ok, I like this and I want to be able to do this'!

Trista, whose father was also in technology talked about not ever having to pay to get things fixed related to games and technology since he was the "handyman". Trista also discussed how tools and equipment would always lie around the house and that as a result, she was perpetually in a setting related to technology. Chloe's father was an electrician and she reported, "Outside of work he was always fixing or improving things within our house, so I was exposed to it at home just watching him do it for fun because he wanted to." She also mentioned being exposed to all kinds of equipment around the house related to her father's work.

Two of the students mentioned above and one additional student talked about seeing their father in a work environment and how that encouraged them regarding STEM. For example, Chloe talked about her dad having his own shop and showing her tools and different boats he was fixing. Haley said, "So, he will take us up to the top floor of the hotel where there's air conditioning, all the machinery, and he would show us around the place and what he does."

Encouragement from mother.

Within the current study, 12 female students (75% of participants) indicated that they had a female parent who encouraged them to pursue a STEM related career. Six major themes emerged from the analysis: STEM resources; verbal praise/encouragement; STEM career role model; continuous engagement; homework assistance; and STEM learning/career conversations.

STEM resources.

Nine students referred to receiving STEM related resources from their mothers. Sometimes these resources were mentioned as material possessions, such as Bianca referring to the purchase of STEM related kits, and Rachel referring to books. Other times these resources were in the form of camps and trips. For example, Beth talked about being able to attend a camp related to her mother's job in STEM. Grace, Evie and Iris talked about their mom planning trips to various science related sites such as museums and parks. In relation to mathematics, Liz also mentioned that her mother pushed her, "… to go to tutoring sessions, study sessions… she'll pay for tutoring services to come and help me with that."

Verbal praise/encouragement.

Verbal praise was experienced by eight of the interviewees. For three, this took the form of mothers telling their daughters' that they are capable and can overcome challenges in STEM. For example, Liz referred to her mother as having said, “This is hard, but it’s doable. You can do it!” Jen talked about her mom reminding her that she could do STEM related activities even when she thought she could not. Five others referred to general forms of STEM encouragement or receiving an extra push or encouragement. Iris indicated, “My mom just always pushed me.” Beth talked about her mom always being by her side and offering encouragement.

STEM career role model.

Six female students mentioned that their mothers provided opportunities for encouragement through their employment in STEM related fields. Dina talked about how she was inspired by her mother’s ability to “stick to it” when she was going to college to complete her degree in environmental science. She also mentioned, “… seeing her do that despite my grandmother and despite what everyone says to her, she stuck to it…. how passionate she was. I wanted that.” Evie talked about how her mom worked in an emergency room and noticed her compassion, inspiring her to go into the medical field. Haley also referred to her mother being a physical therapist and making her realize that she also wanted to become a physical therapist. Liz and Pat took it a step further and mentioned going to work with their mothers and observing. Liz said, “I just go in and out of her dental office all the time. I just see what she does. That’s basically how I kind of got interested in it from seeing her in her work.” Pat also indicated that she went to work with her mother who was a home health nurse. Through her observation of how her mother took care of her patients, Pat’s interest in the field was heightened.

Continuous engagement.

Although most of the students that indicated they had encouragement from their mothers in STEM implied the continuous nature of the support, six students directly spoke about how their mother continued to encourage them later in life. Dina discussed her mom's consistent mentorship and mentioned that when she was a teenager, she observed her mom complete a STEM degree. Liz talked about seeing her mom as a dental hygienist when she was younger and then her mother advising her about STEM careers later. Trista discussed how she had changed her career aspirations over the years and how accepting her mother was and how she continued to support her, sharing, "She was the one who was the backing force behind me being encouraged to go to higher education. I think she was a bit more, … like inspiring, like you don't want to let her down".

Homework assistance.

Of the group of students that identified as having received encouragement from their mothers, four indicated that they received homework help. Beth, Liz, Bianca, and Pat talked about receiving help in STEM related classes. Beth took it a step further and reported that her mother would listen to her talk about the science learning that took place at school and provide feedback saying, "She helped me with science homework … she would talk to me about the processes I was learning and since she also understood. She would always just support me and help me learn and continue teaching science related stuff".

STEM learning/career conversations.

Four students reported that they were involved in STEM learning conversations with their mothers. Beth referenced that her mother would always talk to her in scientific terms and would teach her science related material outside of school. Liz, Haley, and Pat referred to being involved in talks related to STEM careers and course taking. Liz indicated that her mom would provide insight related to her college experience and taking classes. Haley said, “She would talk about how she wanted to get into the program and how the program was really hard.” Pat described how her mom discussed the medical field with her and referred her to friends with children in medicine.

Encouragement from elementary school teacher.

Of the participants included in the present study, six (38% of participants) indicated that they received encouragement to pursue a STEM related career from their elementary school teacher. Four themes emerged from analysis: continuous engagement; verbal praise/encouragement; engaging teaching styles; and participation in STEM-related activities.

Continuous engagement.

Four students mentioned the continuous engagement with specific elementary school teachers and for one, the memory of material that she incorporated in her lesson. Three students indicated that they kept in touch with their teacher. Susan reported that she has her teacher’s phone number and email and has been told to reach out to her if she needs anything. Beth said, “I would talk to her and would tell her I’m still interested and everything. She always encouraged me in elementary and further on." Jen took it a step further to talk about the continuous impact of a "catchy" song on the scientific method that she remembers from her teacher's class. She mentioned using it in a recent STEM course. "The other day in biology lab we were asked what the scientific method was, I and kept thinking to myself like the song in my head… I really remembered it forever as you can see, because I'm still singing it, even today."

Verbal praise/encouragement.

Three students indicated that they received verbal praise/encouragement from their elementary school teacher. Wanda referred to her teacher telling her, "You're really good at math. You should really go into something with math. You should really go into scientific and engineering kinds of fields. You'll do really good." She also mentioned that receiving praise from a person in authority was very encouraging. Susan indicated, "… she saw potential in me… she influenced me in understanding that I have, maybe the potential and that I was encouraged and appreciated." Beth referred to her teacher as knowing she was interested in science and encouraging her not to lose interest.

Engaging teaching style.

Three students indicated that they became interested and encouraged in STEM due to their teachers' instructional styles. Jen talked about how the teacher would involve them in group projects and include hands-on experiments along with videos and songs. "We would always have some kind of a hands-on experiment… she was always showing us videos or songs about science just to make it fun so that we wouldn't get bored, of course." She even mentioned still singing one of the songs currently to help her remember concepts. In the same way, Grace talked about her gifted teacher making her elementary school STEM experience memorable. “So, her making it so appealing and interactive and positive really did make me have a good baseline and a positive baseline for what I was going to go for in the future”.

Participation in STEM activities.

Two students referred to being encouraged by their elementary school teachers to participate in specific STEM related activities. Beth said, “She was always encouraging me to do science related stuff that I enjoyed, and she was always teaching. So, I think that from a very small age this stuck so it helped me continue later on.” Susan discussed how her elementary school teacher encouraged her to participate in the school science fair and to put more “effort and emphasis”. She shared that her teacher helped her through the process and ended up going with her to the science exposition. “She was great. She would help me whether it was inside school, outside school.”

4.8. Discussion

From the findings in the current study, direct connections to the theoretical frameworks were observed. To begin with, the identity model described above is inclusive of performance/competency, recognition, and interest. Emerging themes and actual students’ reports reflected that students felt competent, recognized, and interested as a result of their participation in specific early activities. These student descriptions and themes motivated the inclusion of the third column in *Table 11* to show the connections between the themes and the identity theoretical framework.

Furthermore, due to similarities between self-efficacy and performance/competency, self-efficacy motivators were perpetually present in the emerging themes and student reports, albeit in different ways depending on the case. These motivators of self-efficacy include sources such as, mastery, vicarious experiences, social persuasions, and emotional and psychological states (Bandura, 1986, 1997; Usher & Pajares, 2006). Since self-efficacy is related to performance/competency, these motivators will be discussed in subsequent paragraphs to further explain the relationship to performance/competency as reflected in *Table 11*.

The students' descriptions of each of the early positive experiences alluded to them being sources of STEM capital or accumulated assets. Furthermore, students described that they continued to engage in many of their early experiences, outside of their elementary school years. For example, students spoke about engaging in *watching STEM-related TV programs or movies* repeatedly over their middle and high school years and beyond. Furthermore, some described how their interest, competency/performance and overall STEM identity continued to be impacted as they consistently engaged in *watching STEM-related TV programs or movies*. These connections were evident throughout the analysis and inspired the addition of the fourth column of *Table 11* to reflect links to STEM capital and STEM identity capital.

Table 11

Emerging Themes and Link to STEM Identity and STEM Capital/Identity Capital

Experiences	Themes	Link to STEM Identity	Link to STEM Capital and STEM Identity Capital
Another Relative in STEM	1. Quorum 2. Mentorship	1. Interest 2. Performance/Competency Recognition	Capital
Using STEM toys/kits (e.g., building/construction sets, circuit boards, model rockets, science kits)	1. Hands-on Experience 2. Heightened Emotions 3. Influence of Other People 4. Continuous Engagement	1. Interest 2. Interest Performance/Competency 3. Recognition, Performance/Competency 4. Performance/Competency	Capital and Identity Capital
Watching STEM-related TV programs or movies (documentaries, dramas, sci-fi)	1. Heightened Emotions 2. Continuous Engagement 3. Cognitive Engagement 4. Future Connections 5. Influence of Other People	1. Interest Performance/Competency 2. Performance/Competency 3. Performance/Competency 4. Performance/Competency 5. Recognition, Performance/Competency	Capital and Identity Capital
Playing STEM computer/video games	1. Heightened Emotions 2. Influence of Other People 3. Reward 4. Agency 5. Cognitive Engagement 6. Continuous Engagement	1. Interest, Performance/Competency 2. Recognition, Performance/Competency 3. Recognition 4. Performance/Competency 5. Performance/Competency 6. Performance/Competency	Capital and Identity Capital
Observing or studying stars and other astronomical objects	1. Heightened Emotions 2. Influence of Other People 3. Hands-on Experience	1. Interest Performance/Competency 2. Recognition Performance/Competency 3. Interest	Capital
Baking/cooking/kitchen chemistry	1. Cooking with mother 2. Hands-on Experience 3. Continuous Engagement	Unrelated to STEM Identity	Unrelated to Capital and Identity Capital
Writing about STEM, including creating online blogs/podcasts/videos	1. School Assignment	Unrelated to STEM Identity	Unrelated to Capital and Identity Capital
Encouragement from father	1. Verbal Praise/Encouragement 2. Homework Assistance 3. STEM Resources 4. Continuous Engagement 5. STEM in Daily Life	1. Performance/Competency Interest 2. Performance/Competency 3. Performance/Competency, Recognition 4. Performance/Competency, 5. Performance/Competency Interest	Capital and Identity Capital
Encouragement from mother	1. STEM Resources 2. Verbal Praise/Encouragement 3. STEM Career Role Model 4. Continuous Engagement 5. Homework Assistance 6. STEM Learning/Career Conversations	1. Performance/Competency Interest 2. Performance/Competency Recognition 3. Performance/Competency, Interest 4. Performance/Competency 5. Performance/Competency 6. Performance/Competency	Capital and Identity Capital

Encouragement from elementary school teacher	1. Continuous Engagement 2. Verbal Praise/Encouragement 3. Engaging Teaching Style 4. Participation in STEM Activities	1. Performance/Competency 2. Performance/Competency, Recognition 3. Performance/Competency, Interest 4. Performance/Competency	Capital and Identity Capital

Research Question #1

The experience of having, *another relative in STEM,* functioned as an asset that assisted in developing students' identity in STEM. Within the present study, findings reveal that for many students, relatives inspired them through serving as mentors and providing opportunities to talk about and observe them at work in their careers. These vicarious experiences through relatives, can significantly impact self-efficacy (Usher & Pajares, 2006) and contribute to the building of performance/competency. Students also referred to receiving verbal encouragement while others mentioned that relatives provided resources such as books related to STEM. The self-efficacy motivators, direct and indirect social persuasion respectively, are evident in these experiences, since relatives can provide messages related to STEM that can impact attitudes and confidence, thereby influencing performance/competency (Usher & Pajares, 2006).

Most students also reported that they had more than one relative in STEM. The existence of more family members in STEM may serve to positively influence students since they have access to more individuals to encourage them and assist with increasing their interest and enthusiasm about pursuing STEM-related careers. Although sparse, the literature highlights that some students are inclined to pursue occupational fields in which multiple family members are employed (Banks & Bailey, 2010). After indicating she had multiple family members in STEM, Wanda's comment sums it up perfectly when she indicated that she wanted to be like her family members and make decisions on what suits them.

Having another relative in STEM served as a source of capital. Some students clearly reported that having other family members at their disposal influenced them to begin and/or persist with a STEM career. Students were able to obtain social capital from networking with relatives employed or preparing for STEM careers, as well as cultural capital available from the resources that relatives provided such as, STEM books and kits.

Research Question #2

The second research question relates to identifying how the lived experience of early STEM experiences connects to female students' STEM identities and STEM career intentions. The early lived experiences that were examined in terms of their positive relationship to STEM identity are: *using STEM toys/kits; watching STEM related TV programs or movies; playing STEM computer/video games; observing or studying stars and other astronomical objects; encouragement from father; encouragement from mother;* and *encouragement from elementary school teacher.* None of the students spoke negatively about any of these early experiences. The early lived experiences that were reported as unrelated or not affecting STEM identity are: *baking/cooking/kitchen chemistry*, and *writing about STEM, including creating online blogs/podcasts/videos.* In this section a discussion will be completed related to the early STEM experiences excluding encouragement (father, mother, elementary school teacher). Then there will be an examination of the early STEM experiences that relate to encouragement.

Early Experiences (excluding Encouragement)

Two common themes that were present in all the experiences that were positively related to STEM identity are *heightened emotions* and *influence of other people*. The way that students reported *heightened emotions* suggested that these emotions had bearing on two different identity constructs: interest and competency/performance. In specifically viewing interest, when students spoke of their enthusiasm about participating in these specific STEM related activities, they used words like exciting, inspiring, and fascinating. Some also mentioned increased interest in selecting STEM related careers. Similar findings and/or discussions are present in the literature (Bandura, 1986; Hazari et al., 2017). *Heightened emotions* were also tied to students' self-efficacy, since their enthusiasm about and successful participation in STEM related activities impacted their performance/competency. According to Usher and Pajares (2006), "Students often interpret their physiological arousal as an indicator of personal competency… in general, increasing individuals' physical and emotional well-being and reducing negative emotional states strengthens self-efficacy" (p. 127). Some of the students reporting their lived experiences shared their excitement about wanting to complete more research and learn even more about STEM concepts. Their interest led them to seek methods of becoming more competent in STEM areas such as when Jen referred to her increasing interest in researching topics like cell function.

For the most part, *influence of other people* allowed students to be recognized in STEM. Many of the students reported that they had family members, peers, teachers, and friends who acknowledged them as being interested in STEM. Recognition in STEM is

"… vitally important to how the student sees her/himself and her/his subsequent choices" (Hazari et al., 2010, p. 979). When students are acknowledged in a specific area, it builds their self-efficacy and impacts performance/competency. Some of the students also mentioned that people influenced them by being active participants in their STEM journey, such as assisting them with STEM projects and just being a general source of support and model for them in STEM. From the reporting of students, many of these people provided social persuasion messages (Klassen, 2004; Usher & Pajares, 2006) that in turn influenced their performance/competency.

Watching STEM-related TV and *playing STEM computer/video games* both included the theme *cognitive engagement*. Studies indicate that when students are engaged in watching television (Chen & Cowie, 2016; Penuel et al., 2010) and playing computer/video games (Abdul Jabbar & Felicia, 2015), they gain knowledge related to scientific topics. Engagement and building of understanding and mastery of concepts can influence students' beliefs in themselves and their capabilities related to STEM (Bandura, 1986), thereby impacting their competency/performance in STEM related fields.

Both *using STEM toys/kits* and *observing or studying stars and other astronomical objects* included the theme, *hands-on experience* where students spoke about physically manipulating scientific instruments and objects. According to the literature, one resulting factor of participating in hands-on experiences is increased interest (Gibson & Chase, 2002; Thompson & Soyibo, 2002). Interest in STEM related experiences is inextricably tied to STEM identity (Hazari et al., 2010) and further studies indicate that when students are interested in STEM disciplines, they are more likely to pursue STEM related careers (Adams et al., 2006; Fouad & Smith, 1996).

Two early experiences were reported as not related to STEM identity. In discussing the experience of *baking/cooking/kitchen chemistry*, most of the female students recognized it as an activity that they engaged in with their mothers. When specifically asked if they saw any connections to STEM, they mentioned that they did not see a relationship and that it did not affect their interest in STEM. Therefore, from these findings, there is no connection between the activity and the fostering of STEM identity in the female students within the study. Although many of the students mentioned that they still bake and cook and consider themselves to be good at it, they did not report that their continued engagement in this activity as interacting and impacting their current STEM identity.

It is salient to note that students' experience with *baking/cooking/kitchen chemistry* is associated with their mothers and baking and cooking is stereotypically gendered to females (Luxton, 1980; Mayne, 2000; Meah, 2014). Therefore, at some level, the activity may negatively impact their STEM identity since many STEM fields are typically gendered as more masculine (Chambers, 1983; Kessels, 2005; Makarova & Herzog, 2015). The adverse impact may explain why this variable was negatively related to STEM identity in the previous study (Chapter 3). However, in the current study none of the students verbalized or implied that they saw *baking/cooking/kitchen chemistry* as negatively affecting their STEM identity.

The two students that talked about *writing about STEM* reported that the activity was related to class assignments and lacked a robust STEM-writing connection. These findings underscore the need for teachers to seek alternative methods of incorporating writing as a learning tool in STEM, not only to increase literacy, but to confirm understanding of STEM concepts (Firmender, Casa, & Colonnese, 2017; Prain, 2006; Rivard & Straw, 2000). Additionally, educators must find ways to bridge the gap between writing and technology where students complete writing on-line and connect it to their STEM studies. For example, in a study completed by Choi, Hand, and Norton-Meier (2014), students participated in online argumentation using a science writing heuristic approach. Children read and wrote comments on online discussions on topics related to a plant and/or human health investigations. The results indicated that the students were actively engaged and interested.

Neither of these students connected their writing to technology as in writing blogs or creating podcasts or videos even though the previous study (Chapter 3) used these technology-enhanced platforms as examples within the survey item. Many studies point to blog entries and other web-based activities being performed in upper grades (Duran, Höft, Lawson, Medjahed, & Orady, 2014; Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011; Min-Hsiung, Jeng-Fung, & Quo-Cheng, 2011). These results support assumptions from the previous study (Chapter 3) that indicate that creating blogs/podcasts/videos might be developmentally unsuitable for students at a K-4 level (Chapter 3), at least with the current software available for these activities. It might also explain why two other students within the study referred to their participation in this experience during middle and high school and not during their K-4 years. Furthermore, learning science through writing, in general, may be age inappropriate in early elementary school since students are learning to read/write rather than reading/writing to learn; the latter becomes more prevalent in upper elementary school. In the current study none of the students verbalized or implied that they saw *writing about STEM* as negatively affecting their STEM identity.

Early Experiences (Encouragement)

For the students that reported receiving encouragement from their father, mother, and elementary school teacher, there was a common theme, *verbal praise/encouragement*. The theme is connected to STEM identity since it influences students' performance/competency as well as recognition. Words of affirmation received from individuals that students' hold in high esteem can be a significant source of social persuasion that contributes to the building of self-esteem (Bandura, 1986; Usher & Pajares, 2006). Many students also reported being recognized as STEM people by their fathers, mothers, and elementary school teachers. Recognition is connected to students' STEM identity and is pivotal in how they begin to see themselves in STEM and their perception of how others see them (Carlone & Johnson, 2007).

Many of the students indicated that they were influenced through their fathers' involvement with STEM in everyday life. For these students, their fathers not only worked in STEM related careers, but they also participated in STEM related practices around the home, like fixing computers and broken items. Students also mentioned visiting the STEM workplace of their mothers and fathers. Surprisingly, with the limited number of women in STEM and related stereotypes, many students viewed their mothers as STEM career role models. Some even mentioned their mothers successfully navigating hardships while preparing for STEM fields. This example of determination and perseverance can strongly impact young girls, setting the stage for the building of identity, specifically in STEM. These findings are consistent with literature that indicates that fathers (Hellerstein & Morrill, 2011; Van de Werfhorst, & Luijkx, 2010) and mothers (Jacobs et al., 2017; Treiman & Terrell, 1975) who are employed in STEM careers can act as role models to their daughters and encourage them to pursue similar careers.

Parental career influences vicariously impact students which leads to strengthening of self-efficacy and bolstering of competency/performance (Bandura, 1986; Schunk, 1987; Usher & Pajares, 2006). Additionally, vicarious experiences can change students' course for successfully accomplishing STEM-related tasks. "Observing competent models perform actions that result in success conveys information to observers about the sequence of actions one should use to succeed" (Schunk, 1987, p. 151).

The themes providing STEM *homework assistance and resources,* were also common to students who reported encouragement from mother and/or father. With respect to homework assistance, previous studies indicate that parents can provide successful homework support to their children (Larson & Richards,1994; O'Brien, 2007). Likewise, in viewing STEM resources, the findings from the current study are consistent with the literature, where studies indicate that parents provide tangible resources such as purchasing tablet devices (Baker, 2014) and intangible resources such as investing time (Gadzikowski, 2015). Additionally, they may create opportunities for enriching after school activities or tutoring (Gann & Carpenter, 2019). Students' successful encounters with STEM related experiences and resources can strengthen their understanding of STEM related concepts and enable them to have improved performance in STEM (Master et al., 2017; Mooney & Laubach, 2013). Improvement in content knowledge can result in the strengthening of STEM identity. Furthermore, according to Funk and Hefferon (2016), students' early curiosity and interest can be related to parents and other family members providing opportunities for them to participate in STEM related activities. Students' interest can directly influence their STEM identity.

One theme that only appeared in the analysis for students that had mothers as a source of encouragement was having *STEM learning/career conversations*. Within the literature, some studies indicated that mothers are reported as talking more to their daughters and providing encouraging conversations (Leaper, Anderson, & Sanders, 1998). The relationship might explain why more daughters gravitate to their mothers for career advice and talks about their learning. Additionally, since mothers are more involved in their children's academic progress (Murray et al., 2006; Shumow & Miller, 2001), it might be logical for students to have conversations with them. In the current study, mothers' providing STEM learning/career conversations allowed students' competency/performance to be strengthened as students received social persuasion messages from these conversations as well as vicariously experiencing their mothers' successes within STEM careers.

Two themes that appeared only in *elementary school teacher encouragement* were *participation in STEM activities* and *engaging teaching style*. The students that mentioned their teacher provided the first source of encouragement indicated that they participated in activities that were science-related with that teacher and discussed how their teacher encouraged their participation. The students that mentioned engaging teaching style referred to the interactive and hands-on nature of these activities. Both methods of encouragement that these students received from their teachers can build their STEM identity through influencing their performance/competency. Additionally, a hands-on, agentic approach to learning has been known to affect students' interest in STEM (Riegle-Crumb, Morton, Nguyen, & Dasgupta, 2019).

All the positive predictors mentioned within this discussion served as sources of STEM capital for students in that these experiences enabled students to have advantages within a STEM environment. Interestingly, of all the case factors discussed in the current study, mothers' encouragement was mentioned most often by the students (75% of all participants) and is therefore the most frequently reported source of STEM capital. These results highlight the salient role that mothers play in providing continuous support and providing situations to nurture their daughters' STEM identity (Mireles-Rios & Romo, 2010).

Research Question #3

This question addresses how specific early experiences continue to affect female students' STEM identities years later. Apart from *observing or studying stars and other astronomical objects*, the positive lived experiences included the theme, continuous engagement. In viewing the positive factors (excluding encouragement), students identified that after their K-4 years, they continued to engage in those activities and that this engagement consistently impacted their identity. For example, some students spoke of *watching STEM-related TV programs or movies* as a child to understand STEM related concepts, and still currently using this source to gain scientific knowledge. The students that mentioned that they received encouragement from parents and/or elementary school teacher, referred to how these individuals constantly engaged in their lives. For parents, they spoke of fathers and mothers perpetually guiding them and providing experiences and opportunities for them to excel in STEM fields. For elementary school teachers, some discussed their contact with teachers over the years and use of resources that their elementary school teachers originally provided.

As described within the theoretical framework, STEM experiences and resources that continue to have an impact on identity over time and space, are contributors to STEM identity capital. Therefore, in the present study the following early experiences contributed to the strengthening of STEM identity capital: *using STEM toys/kits; watching STEM-related TV programs or movies*; *playing STEM computer/video games; encouragement from father; encouragement from mother; encouragement from elementary school teacher.* The themes that emerged from analyses indicate that these early experiences are hands-on and agentic in nature, allow for heightened emotions in students, and provide opportunities for future career connections. In addition, individuals that provide encouragement and continue to support students over the course of their school years deeply impact the development and future strengthening of positive STEM identity.

In viewing the construct *observing or studying stars and other astronomical objects*, one reason why it might not have survived as a form of identity capital is the lack of interest and student participation in these types of activities in middle and high school. In the analysis, the students did not refer to continually participating in the activity. These findings are bolstered by previous studies that reflect the decrease in involvement of students in high school astronomy related classes (Krumenaker, 2009, 2010). In addition, some of the students in the study referred to performing the activity with a family member and potentially bonding with family. As they continue to develop through their school years, students may become less interested in family time and more interested in spending time with their peers (Fuligni, Eccles, Barber, & Clements, 2001; Larson & Richards, 1994).

4.9. Limitations and Future Studies

The present study has some limitations. First, it includes a group of female students at one institution and the races represented are white, black, and multi-racial. Therefore, the results are limited since they cannot represent the lived early STEM experiences of female college students pursuing STEM degrees nationwide. Second, these female students are currently in college and may find it difficult to remember specific details of experiences during their K-4 years. Future studies should focus on younger children with respect to these experiences and follow them longitudinally to understand how they continue to shape STEM identity over time. However, the advantage of the approach in the current study is that the experiences and details that they do report are prominent and memorable, reinforcing their personal authenticity for participants and bolstering credibility when particulars of the early experiences overlap across participants. Finally, since the data is self-reported, it becomes susceptible to biases, such as social desirability (Gonyea, 2005). Further qualitative gender studies will be helpful to view how male and female students in STEM compare in their participation of K-4 STEM activities and how these experiences affect identity and evolve over time.

Conclusion

The present qualitative study was conducted as a follow up to a previous study related to how parental occupations and early STEM experiences can affect female students' STEM identity and career intentions. In the current study, female students described their lived experiences with specific factors and these experiences were found to be linked with STEM identity/identity capital in different ways. The experiences that were positively related to their STEM identity, include, *using STEM toys/kits*; *watching STEM-related TV programs or movies*; *playing STEM computer/video games*; *observing or studying stars and other astronomical objects; encouragement from mother, father and elementary school teacher*. On the other hand, students viewed *baking/cooking/kitchen chemistry* and *writing about STEM* as unrelated to the development of their STEM identity. In analyzing students' descriptions of their early experiences, specific themes emerged to reflect how and why these experiences might be impactful. Experiences that were hands-on, where students' emotions were heightened, and they were cognitively engaged, proved to be positive and beneficial. On the other hand, when activities were not agentic or presented as unconnected to STEM, there was no impact or effect on identity or identity capital. Many of the early experiences served as identity capital and continued to affect students' STEM identity in later years because of continued engagement or use of the early experience as a resource.

These findings have significant implications for STEM educators and administrators. They can serve as mentors to students who may lack accumulated capital from having other relatives in STEM. They can build meaningful relationships with students that extend beyond being just role models. Rather, they can impact students through providing tangible and intangible resources, verbal encouragement, and continuous engagement. Teachers who are interested in facilitating learning from a student-based, agentic perspective may use the significant experiences found in the study as a baseline. Furthermore, they can repeatedly draw on students' prior knowledge and continue to engage them in positive STEM experiences, as embodied in a spiral curriculum. These findings might also be relevant to parents and after school program leaders as they utilize experiences that have lasting effects on female students' STEM identity and assist with persistence in STEM.

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CHAPTER 5

CONCLUSIONS

In this section, I will provide a summary of my collected papers dissertation along with results and significant connections. Then, I will describe intellectual merit and implications before addressing directions for future work.

5.1. Summary of Research Findings

The connected studies in my dissertation provide a comprehensive view into how familial occupations and early STEM experiences can impact STEM identity/identity capital and career intentions. The first paper (Chapter 2) focused specifically on familial employment in STEM and the relationship to STEM career intentions. Two regression models were created, one to examine the individual effects, and another to test quorum effects of having multiple family members employed in STEM occupations. The results indicate that there was a significant effect for students who had fathers, siblings, and other relatives in STEM occupations. A significant quorum effect was found suggesting that the more family members students' have in STEM, the greater the likelihood of them selecting STEM related careers. Gender interactions were observed where having a sibling in STEM had no effect for female students but was significant for male students. In addition, having a quorum of relatives in STEM occupations was more predictive for male students than female students. The first paper set the stage for further exploration and highlighted the need for a more in-depth analysis and additional theoretical framing to understand how these familial occupations might relate to the development of STEM identity in students. In addition, given the expansive literature on formative in-school and out-of-school STEM experiences, I was inspired to expand my focus to include other experiences that might be important for students in the earlier years of their lives. This involved examining the effects of different types of early STEM experiences that students encounter during their K-4 years, and the impact of these experiences on their developing STEM identity.

The second paper (Chapter 3) addressed the relationship between STEM identity and career intentions, and then examined how familial STEM occupations and early experiences were linked to STEM identity. The study included another theoretical dimension, STEM identity capital, and considered how specific early experiences can exist as consistent influencers of STEM identity across space and time. Four regression models were created and the results from the final model indicated that there were significant effects for having another relative in STEM, encouragement from parents and elementary school teachers, and specific early STEM experiences. These early experiences that were positively related to identity included *using STEM toys/kits*; *watching STEM-related TV programs or movies*; *playing STEM computer/video games*; and *observing or studying stars and other astronomical objects.* On the other hand, the experiences that were negatively related to identity included: *baking/cooking/kitchen chemistry;* and w*riting about STEM, including creating online blogs/podcasts/videos.* Remarkably, the activities that were positively related to STEM identity were more likely to be student driven and agentic in nature, while the ones that were negatively related appeared to lack autonomy and might be implemented in developmentally unsuitable ways for K-4 students. Several other hypotheses were made regarding why specific familial STEM occupations and early experiences might have been significant, but other than references to related studies in the literature, there were no first-hand accounts from students to help explain how and why these experiences might have been significant for them. Since women are underrepresented in STEM-related fields and the findings that female students were less involved in activities that build STEM identity, and more involved in activities that negatively affect STEM identity, I was motivated to complete a follow-up qualitative study to gain a deeper understanding of the results and to further explain how these experiences relate to STEM identity/identity capital and career intentions for women.

The third paper (Chapter 4) presented phenomenological case studies where each early experience was considered a specific case. Only female students were interviewed, and each student described her lived experiences related to specific early STEM activities. The data were analyzed, and themes emerged. These themes allowed for significant insight into how early lived experiences impacted female students' STEM identity. The study highlighted the multiple support roles played by mothers and fathers in young women's STEM trajectory as well as idiosyncratic roles played by other family members. In support of the first study that found a sibling's role was only significant for male students, there was a dearth of lived experience mentioned by these young women in the surveys and interviews with regards to siblings. For the early STEM experiences that were formative as STEM identity capital later in life, they generally shared a common feature with respect to continued engagement in the experience over time or the drawing upon the experience as a resource later in life to help support future learning. The formative early experiences often shared other thematic features such as being hands-on and causing heightened emotions and cognitive engagement.

There were noteworthy similarities in findings across the three papers even though different forms of data were utilized. All three papers reported that having another family member in STEM was significant. This result is supported in the literature where studies reveal that students have been influenced by extended family members (Banks & Bailey, 2010; Beck, 2000; Shattell, Moody, Hawkins, & Creasia, 2001). In addition, the findings in paper one (Chapter 2) indicated that having a father in STEM was significantly related to career intentions. Within paper two (Chapter 3), the same result was found in the second regression model. However, when early STEM experience variables such as father encouragement were added, father in STEM became non-significant by the final model. The result was expected, since it is very likely that fathers who are employed in STEM are inclined to encourage their children in STEM. This result is bolstered by findings in paper three (Chapter 4) where most of the students that reported their fathers as being employed in STEM also identified their fathers as encouragers. Both papers one (Chapter 2) and three (Chapter 4) confirmed the importance of having a quorum of family members in STEM and the impact of having STEM influence from multiple family members.

While paper three (Chapter 4) focused on participants who reported having the formative experiences found in paper two (Chapter 3), it also independently confirmed the positive nature of certain experiences. The two negative experiences found in paper two were found in paper three to be mostly unimportant for participants in terms of engagement in STEM. As such, additional hypotheses are posed with supporting literature as to why these experiences may have been negative. There are observed consistencies across the second and third papers in relation to the theoretical framework and research findings. In paper two, I described a nuanced perspective on an identity capital framework (Côté, 1996), and theorized how the framework can be used to determine how STEM identity capital can maintain and impact identity across space and time. Results from the employed regression models revealed that specific early experiences existed as contributors of STEM identity capital after controlling for middle and high school experiences. Within paper three I switched to a different methodological framing, yet similar results were apparent where a theme of *continuous engagement* appeared in all the same positive experiences identified in paper two. The theme emerged as a result of reports from female students indicating that these early experiences were utilized later in life and served to continually impact their identity. Therefore, the results from papers two and three complemented each other irrespective of methodology.

5.2. Intellectual Merit and Implications

My dissertation as a whole incorporated a novel framework utilizing three widely discussed concepts: STEM capital, STEM identity and STEM identity capital. The framework, as viewed from a STEM domain, highlighted how early STEM experiences can build capital and identity in students. In addition, it integrates a nuanced perspective in identifying how STEM identity capital can coexist as a constant reinforcement for STEM identity across time. Through building and applying a theoretical model (Figure 2) in these dissertation studies, I was able to observe first-hand how the concepts intermingle as students accumulate capital and build and reinforce STEM identity. The model is a straightforward representation incorporating the role of each concept and can be easily employed and expanded in future studies, thus significantly contributing to educational research.

The theory of STEM identity capital has significant implications. To begin with, STEM identity work indicates that STEM identities are fluid and they can be impacted in the moment and across time and space (Barton et al., 2013). Some early STEM experiences serve to only affect identity in the moment while others have both momentary and lasting effects. The theory of STEM identity capital provides an avenue to pinpoint those experiences that have long-term effects on STEM identity and enables understanding into the nature of those experiences. For example, if students are involved in the early experience of *tinkering with mechanical objects*, STEM identity capital lens allows the opportunity to reflect on characteristics that embody the experience and to determine if that experience translates as a continuous contributor of STEM identity.

There are also implications related to these experiences that exist as sources of STEM identity capital. Not only are these experiences important for the development and strengthening of STEM capital, but also for the maintenance of STEM identity. Through these studies, I have ascertained that these types of experiences are extremely valuable to students in their pursuing and persisting toward STEM related careers. Therefore, it is salient for students to engage in these types of experiences during their elementary school years either in school and/or after school. Within the school system educators can be impactful influencers through their methods of facilitating engaging teaching/learning practices (Flannagan & McMillan, 2009; Wood & Ashfield, 2008). As consistent with characteristics attributed to experiences that exist as contributors to STEM capital and

STEM identity capital, teachers might find it helpful to introduce agentic activities such as those that offer opportunities for autonomy and growth. These types of experiences help to increase interest and secure lasting effects (Demski, 2009; Dhingra, 2006). Students can also be encouraged to explore similar activities outside of school setting, independently or with relatives and/or friends.

The studies in my dissertation provide valuable information related to the types of early experiences that lend to the development of identity. Although it is unknown whether these experiences originate in the classroom or outside of school hours, their impact still resonates. Many of the activities that are positively related to STEM identity are agentic in nature. For example, many times when students use STEM toys/kits, they might be operating under autonomy as they assemble, construct, and manipulate the individual pieces (Karp & Maloney, 2013; Mauch, 2001). In the same way, when they play STEM computer/video games, they might build their own characters and/or might choose from a variety of mission selections (Sandford, Ulicsak, Facer, & Rudd, 2006). In the realm of education this information is valuable. It may be useful to policy makers who monitor the success of the education system and can recommend changes in teacher education and curricula content. It might also be beneficial to STEM program leaders outside of school to know the types of activities to implement.

Major findings in these studies indicate that having family and/or extended family members in STEM as well as having elementary school teacher encouragement are both significantly related to STEM identity (Chapters 2, 3, 4). In a school setting, educators become increasingly aware of the home environment associated with their students. In determining students that lack capital from not having access to family members employed in STEM related careers, educators can seek ways to provide support and encouragement akin to what they might receive from those family members. For example, they can be available to talk with students and give advice related to STEM, as well as provide avenues for praise and recognition (Bohn, Roehrig, & Pressley, 2004).

Parents and family members might also benefit from becoming familiar with the results from these studies since it will remind them of their influence. Whether or not they are employed in STEM careers, they can still provide encouragement and support for developing students' interest in STEM. The findings from these studies are also relevant to school administrators who play a vital role in the overall success of any STEM-related program. They are pivotal to the successful training of teachers (Bredeson, 2000), implementation of programs (Hallinger & Heck, 1996), and dissemination of information to parents and community members (Khalifa, 2012).

5.3. Directions for Future Work

Future work related to early STEM experiences should be explored and specific attention should be placed on the context of student participation, i.e. in school or out of school. Finding this out can be accomplished by specifically asking (in person or on surveys) where the initial experience might have occurred and its potential impact. Knowing the context of early experiences will assist with determining the roles that the setting and the types of activities play in fostering identity. Furthermore, qualitative studies should consider the viewpoint of male students. Mixed gender qualitative interviews should be completed to provide a comparison of the impact and effects of familial occupation and early experiences across genders. Within the literature, studies indicated that early experiences can be different for girls than boys (Archer et al., 2012; Capobianco, Yu, & French, 2015; Carrier, 2009; Cvencek, Meltzoff, & Greenwald, 2011).

Within the dataset provided in paper two (Chapter 3), additional constructs can be included for deeper analysis. For example, more familial components such as, family participation in visiting science centers, attendance to STEM events, and talking about STEM can provide more insight into familial STEM involvement. STEM experiences and participation in afterschool programs can also be analyzed at other periods of students' school years, such as 5-8 or 9-12.

Longitudinal studies should be conducted to analyze the impact of early experiences on the same students over a period, since they, "… are extremely useful for studying the dynamics of a topic or issue over time" (Gay, Mills, & Airasian, 2012, p. 185). Data can be collected two or more times and as such should either be gathered twice, during elementary and middle schools, or three times, during elementary, middle and high schools. In this way, an on-going progression of the effects of capital and the impact on identity can be documented, as well as reflections on the continuing impact of STEM identity capital. Results from these types of data would provide a different perspective to enrich the findings of the studies within my dissertation.

5.4. Final Remarks

During my prior years in the teaching profession, I was amazed by the significant number of girls that were interested in STEM related fields during their early years, and how quickly these numbers plummeted as they completed middle school and ventured into high school and beyond. I sought methods of helping these girls maintain their enthusiasm and persist through their later school years, but it became an overwhelming and ominous task. For countless educators, who share a similar sentiment of significantly impacting young girls so that they can build robust STEM identity, powerful enough to help them persist, the findings in my dissertation provide a glimmer of hope and a clear path towards early avenues that impact STEM identity and may help to address female underrepresentation in STEM fields.

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APPENDICES

Appendix A: Sustainability and Gender in Engineering (SaGE) Survey (Chapter 2)

Clemson University

Engineering and Science Education

SaGE:

Sustainability and Gender in Engineering

Information Regarding Participation

We are interested in your experiences learning science. By filling out this questionnaire, you will help us find ways to improve science education for future students. Please make your best estimate for each item and answer as many questions as possible. There are no right or wrong answers; just do your best. Some questions will not apply to your experiences and can be left blank (e.g. questions about a course you have not taken). Please note:

- You must be 18 years or older to participate.
- The survey will take approximately 20 minutes to complete.
- Participation is voluntary. You may withdraw at any time.
- Participation will NOT impact your grade in this course in any way.
- You will be asked for contact information (email) in case we want to follow-up on some of your survey responses. This information is voluntary and will not be shared with any third party.
- If you have any questions or concerns, please contact Leidy Klotz (leidyk@clemson.edu), Geoff Potvin (gpotvin@clemson.edu), or Zahra Hazari (zahra@clemson.edu).
- You may contact the Clemson University Office of Research Compliance at 864-656-6460, toll-free at 866-297-3071, or irb@clemson.edu if you have any questions regarding your rights as research participants.

Enter your English course name/number on the line below.

Contact:
Leidy Klotz, Ph.D.

leidyk@clemson.edu

This project is funded by the National Science Foundation, grant number NSF 1036617.

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SERIAL #

SECTION 1: YOUR CAREER GOALS

1. **How important are the following factors for your future career satisfaction?**

	Not at all important 0	1	2	3	Very important 4
Making money	○	○	○	○	○
Becoming well known	○	○	○	○	○
Helping others	○	○	○	○	○
Supervising others	○	○	○	○	○
Having job security and opportunity	○	○	○	○	○
Working with people	○	○	○	○	○
Inventing / designing things	○	○	○	○	○
Developing new knowledge and skills	○	○	○	○	○
Having lots of personal and family time	○	○	○	○	○
Having an easy job	○	○	○	○	○
Being in an exciting environment	○	○	○	○	○
Solving societal problems	○	○	○	○	○
Making use of my talents and abilities	○	○	○	○	○
Doing hands-on work	○	○	○	○	○
Applying math and science	○	○	○	○	○

2. **Which BEST describes what you want(ed) to be in middle school, high school, and college?** *(Mark only ONE choice per column)*

	Middle school	Beginning of high school	End of high school	In college
Medical professional (e.g. doctor, dentist, vet.)	○	○	○	○
Health professional (e.g. nursing, pharmacy)	○	○	○	○
Engineer	○	○	○	○
Environmental scientist	○	○	○	○
Chemist	○	○	○	○
Physicist	○	○	○	○
Biologist	○	○	○	○
Computer scientist/Information technologist	○	○	○	○
Social scientist (e.g. sociologist, anthropologist)	○	○	○	○
Other science-related career	○	○	○	○
Mathematician	○	○	○	○
Science/Math teacher	○	○	○	○
Other teacher	○	○	○	○
Other non-science related career	○	○	○	○

3. **Please rate the current likelihood of your choosing a career in the following:**

	Not at all likely 0	1	2	3	Extremely likely 4
Mathematics	○	○	○	○	○
Science/Math teacher	○	○	○	○	○
Environmental science	○	○	○	○	○
Biology	○	○	○	○	○
Physics	○	○	○	○	○
Chemistry	○	○	○	○	○
Bio-engineering	○	○	○	○	○
Chemical engineering	○	○	○	○	○
Materials engineering	○	○	○	○	○
Civil engineering	○	○	○	○	○
Industrial/Systems engineering	○	○	○	○	○
Mechanical engineering	○	○	○	○	○
Environmental engineering	○	○	○	○	○
Electrical/computer engineering	○	○	○	○	○

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SERIAL #

4. **Which of these topics, if any, do you hope to directly address in your career?** *(Mark ALL that apply)*

- ○ Energy (supply or demand)
- ○ Disease
- ○ Poverty and distribution of wealth and resources
- ○ Climate change
- ○ Terrorism and war
- ○ Water supply (e.g. shortages, pollution)
- ○ Food availability
- ○ Opportunities for future generations
- ○ Opportunities for women and/or minorities
- ○ Environmental degradation

SECTION 2: YOUR HIGH SCHOOL EXPERIENCES

5. **What type of high school did you attend?** *(Mark ALL that apply)*

- ○ Private
- ○ Public
- ○ Public charter
- ○ Private religious
- ○ Magnet school
- ○ Vocational
- ○ Baccalaureate
- ○ Home-schooled
- ○ All male or female
- ○ Foreign high school

6. **How many students were in your high school biology, chemistry, and physics courses?** (If you took multiple courses in a subject, please answer questions in this survey based on the LAST version of the course you took.)

Biology:	○ 1–10	○ 11–20	○ 20–30	○ More than 30
Chemistry:	○ 1–10	○ 11–20	○ 20–30	○ More than 30
Physics:	○ 1–10	○ 11–20	○ 20–30	○ More than 30

7. **Please estimate the distribution of males and females in your last high school biology, chemistry, and physics courses.**

	All females	More females than males	About equal	More males than females	All males
Biology:	○	○	○	○	○
Chemistry:	○	○	○	○	○
Physics:	○	○	○	○	○

8. **In terms of learning the material, these courses required:**

Very little memorization	0	1	2	3	4	A lot of memorization
Biology:	○	○	○	○	○	
Chemistry:	○	○	○	○	○	
Physics:	○	○	○	○	○	

9. **In terms of learning the material, these courses required:**

Very little conceptual understanding	0	1	2	3	4	A lot of conceptual understanding
Biology:	○	○	○	○	○	
Chemistry:	○	○	○	○	○	
Physics:	○	○	○	○	○	

10. **Please indicate whether you did the following as part of your last high school science courses.** *(Mark ALL that apply)*

	Biology	Chemistry	Physics
Used the internet for blogging, twitter, or other social media	○	○	○
Watched science videos	○	○	○
Went on field trips	○	○	○
Participated in outdoor activities	○	○	○
Participated in debates, games, or contests	○	○	○
Kept an organized binder/notebook that the teacher checked periodically	○	○	○
Used clickers or other automated response systems	○	○	○
Completed online assignments	○	○	○
Used computer simulations or applets	○	○	○
Manipulated physical objects (e.g. used model kits)	○	○	○
Spoke with female engineer/scientist visitors	○	○	○
Spoke with male engineer/scientist visitors	○	○	○

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11. **Please indicate how often the following occurred in your LAST high school science courses.**

		Never	Rarely	Monthly	Weekly	Daily
Biology	The teacher lectured to the class	○	○	○	○	○
	We spent time doing individual work in class	○	○	○	○	○
	Concepts/ideas were introduced before formulas/equations	○	○	○	○	○
	We spent time doing small group activities	○	○	○	○	○
	We worked on labs or projects	○	○	○	○	○
	Classmates taught each other	○	○	○	○	○
	Whole-class discussions were held	○	○	○	○	○
	The teacher did demonstrations	○	○	○	○	○
	Topics were relevant to my life (e.g. chemistry at home, physics of sports)	○	○	○	○	○
	You asked questions, answered questions, or made comments	○	○	○	○	○
	Other students asked questions, answered questions, or made comments	○	○	○	○	○
	Teacher called on students for responses (not voluntary)	○	○	○	○	○
Chemistry	The teacher lectured to the class	○	○	○	○	○
	We spent time doing individual work in class	○	○	○	○	○
	Concepts/ideas were introduced before formulas/equations	○	○	○	○	○
	We spent time doing small group activities	○	○	○	○	○
	We worked on labs or projects	○	○	○	○	○
	Classmates taught each other	○	○	○	○	○
	Whole-class discussions were held	○	○	○	○	○
	The teacher did demonstrations	○	○	○	○	○
	Topics were relevant to my life (e.g. chemistry at home, physics of sports)	○	○	○	○	○
	You asked questions, answered questions, or made comments	○	○	○	○	○
	Other students asked questions, answered questions, or made comments	○	○	○	○	○
	Teacher called on students for responses (not voluntary)	○	○	○	○	○
Physics	The teacher lectured to the class	○	○	○	○	○
	We spent time doing individual work in class	○	○	○	○	○
	Concepts/ideas were introduced before formulas/equations	○	○	○	○	○
	We spent time doing small group activities	○	○	○	○	○
	We worked on labs or projects	○	○	○	○	○
	Classmates taught each other	○	○	○	○	○
	Whole-class discussions were held	○	○	○	○	○
	The teacher did demonstrations	○	○	○	○	○
	Topics were relevant to my life (e.g. chemistry at home, physics of sports)	○	○	○	○	○
	You asked questions, answered questions, or made comments	○	○	○	○	○
	Other students asked questions, answered questions, or made comments	○	○	○	○	○
	Teacher called on students for responses (not voluntary)	○	○	○	○	○

12. **Please indicate whether the following occurred in any projects or labs for these courses.** *(Mark ALL that apply)*

	Biology	Chemistry	Physics
I picked the topic	○	○	○
I designed/built something	○	○	○
I orally presented my work to the class	○	○	○
It addressed a community and/or family issue	○	○	○
I integrated ideas and information from various sources	○	○	○

Please continue to the next page

13. **Please indicate whether the following topics were covered in your last high school courses.** *(Mark ALL that apply)*

	Biology	Chemistry	Physics	Other Course(s)
Energy supply (e.g. fossil fuels, nuclear, solar, wind)	○	○	○	○
Energy demand (e.g. in buildings, transportation)	○	○	○	○
Climate change	○	○	○	○
Terrorism & war	○	○	○	○
Water supply (e.g. shortages, pollution, conflict)	○	○	○	○
Population growth	○	○	○	○
Food availability	○	○	○	○
Disease	○	○	○	○
Poverty and distribution of wealth and resources	○	○	○	○
Sustainable development	○	○	○	○
Life cycle analysis	○	○	○	○
Biomimicry	○	○	○	○
Environmental degradation	○	○	○	○
Providing opportunities for future generations	○	○	○	○
Work of female engineers/scientists	○	○	○	○
Under-representation of females in engineering/science	○	○	○	○
Engineering careers, stages, or options	○	○	○	○
Benefits of becoming an engineer	○	○	○	○
Students' stories about engineering/science	○	○	○	○
Teachers'stories about their engineering/science experience	○	○	○	○

14. **How many MINUTES did you spend doing work outside of class each day, on average, for your last high school science courses?**

Biology:	○ 0	○ 5	○ 15	○ 30	○ 45	○ 60 or more
Chemistry:	○ 0	○ 5	○ 15	○ 30	○ 45	○ 60 or more
Physics:	○ 0	○ 5	○ 15	○ 30	○ 45	○ 60 or more

15. **Which, if any, of the following resources did you use during class in your LAST high school science courses?** *(Mark ALL that apply)*

	Biology	Chemistry	Physics
Computer	○	○	○
Graphing calculator	○	○	○
Project supplies/equipment	○	○	○
Non-textbook reading materials (e.g. newspapers, magazines)	○	○	○

16. **What types of questions were you required to answer in your last high school science courses?** *(Mark ALL that apply)*

	Biology	Chemistry	Physics
Required several steps of calculations	○	○	○
Required written explanations/essay responses	○	○	○
Required graphing	○	○	○
Required drawing or sketching	○	○	○
Involved data presented in tables	○	○	○
Involved data analysis	○	○	○
Required new insight and creativity	○	○	○
Had more than one correct response	○	○	○

17. **How interested were most students in the content/topics in your last high school science course?**

Not at all interested	0	1	2	3	4	Very interested
Biology:	○	○	○	○	○	
Chemistry:	○	○	○	○	○	
Physics:	○	○	○	○	○	

Please continue to the next page

18. **How would you rate your LAST high school BIOLOGY teacher on the following characteristics?**

	Low 0	1	2	3	4	5	High 6
Enthusiasm for biology	○	○	○	○	○	○	○
Treated all students with respect	○	○	○	○	○	○	○
Explained ideas clearly	○	○	○	○	○	○	○
Explained problems and answered questions in several different ways	○	○	○	○	○	○	○
Was able to organize lessons and classroom activities	○	○	○	○	○	○	○
Was able to handle discipline and manage the classroom	○	○	○	○	○	○	○
Was available to help students outside of class	○	○	○	○	○	○	○

19. **How would you rate your LAST high school CHEMISTRY teacher on the following characteristics?**

	Low 0	1	2	3	4	5	High 6
Enthusiasm for chemistry	○	○	○	○	○	○	○
Treated all students with respect	○	○	○	○	○	○	○
Explained ideas clearly	○	○	○	○	○	○	○
Explained problems and answered questions in several different ways	○	○	○	○	○	○	○
Was able to organize lessons and classroom activities	○	○	○	○	○	○	○
Was able to handle discipline and manage the classroom	○	○	○	○	○	○	○
Was available to help students outside of class	○	○	○	○	○	○	○

20. **How would you rate your LAST high school PHYSICS teacher on the following characteristics?**

	Low 0	1	2	3	4	5	High 6
Enthusiasm for physics	○	○	○	○	○	○	○
Treated all students with respect	○	○	○	○	○	○	○
Explained ideas clearly	○	○	○	○	○	○	○
Explained problems and answered questions in several different ways	○	○	○	○	○	○	○
Was able to organize lessons and classroom activities	○	○	○	○	○	○	○
Was able to handle discipline and manage the classroom	○	○	○	○	○	○	○
Was available to help students outside of class	○	○	○	○	○	○	○

21. **How frequently have you done the following activities outside of formal courses?**

	Never in my life	1–2 times	3–4 times	5–6 times	More than 6 times in my life
Participated in engineering/science clubs, camps, or competitions	○	○	○	○	○
Tinkered with things (e.g. motors, mechanical devices)	○	○	○	○	○
Built things (e.g. structures, houses)	○	○	○	○	○
Participated in other science/engineering hobbies	○	○	○	○	○
Read/watched science/engineering programs or literature	○	○	○	○	○
Read/watched science-fiction programs or literature	○	○	○	○	○
Presented or gave a poster on science/engineering content	○	○	○	○	○
Explained science/engineering topics to experts (e.g. professionals, teachers)	○	○	○	○	○
Explained science/engineering topics to non-experts (e.g. relatives, peers)	○	○	○	○	○

Please continue to the next page ➡

SECTION 3: SUSTAINABILITY AND YOU

When answering the following question, consider that the term sustainability is defined as "meeting the needs of the present without compromising the ability of future generations to meet their needs."

22. To what extent do you disagree or agree with the following:

	Strongly disagree 0	1	2	3	Strongly agree 4
We can pursue sustainability without lowering our standard of living	○	○	○	○	○
Human ingenuity will ensure that we do not make the earth unlivable	○	○	○	○	○
I feel a responsibility to deal with environmental problems	○	○	○	○	○
Environmental problems make the future look hopeless	○	○	○	○	○
I can personally contribute to a sustainable future	○	○	○	○	○
Pursuit of sustainability will threaten jobs for people like me	○	○	○	○	○
Sustainable options typically cost more	○	○	○	○	○
Nothing I can do will make things better in other places on the planet	○	○	○	○	○
I have the knowledge to understand most sustainability issues	○	○	○	○	○
Climate change is caused by humans	○	○	○	○	○
I think of myself as part of nature, not separate from it	○	○	○	○	○
We should be taking stronger actions to address climate change	○	○	○	○	○

23. How likely are you to do the following:

	Not at all likely 0	1	2	3	Extremely likely 4
Put on more clothes rather than turn up the heat when I'm cold	○	○	○	○	○
Use less water when taking a shower or bath	○	○	○	○	○
Evaluate the necessity of things I buy	○	○	○	○	○
Consider the energy/carbon/ecological impact of my food choices	○	○	○	○	○
Reuse bottles for water, coffee, or other drinks	○	○	○	○	○
Choose public transportation, carpool, bicycle or walk as a means of transportation	○	○	○	○	○
Buy a product because it is environmentally friendly	○	○	○	○	○
Take sustainability related courses in my area of academic interest	○	○	○	○	○
Contribute time or money to an environmental group	○	○	○	○	○
Educate others about the importance of these or similar actions	○	○	○	○	○

SECTION 4: ABOUT YOU

24. To what extent do you disagree or agree with the following:

	Strongly disagree 0	1	2	3	Strongly agree 4
I prefer to focus on details and leave the big picture to others	○	○	○	○	○
I hope to gain general knowledge across multiple fields	○	○	○	○	○
I often learn from my classmates	○	○	○	○	○
I prefer to focus on the big picture and leave the details to others	○	○	○	○	○
I hope to develop my expertise in one specific field	○	○	○	○	○
I identify relationships between topics from different courses	○	○	○	○	○
I analyze projects broadly to find a solution that will have the greatest impact	○	○	○	○	○
I seek input from those with a different perspective from me	○	○	○	○	○
I seek feedback and suggestions for personal improvement	○	○	○	○	○
When problem solving, I focus on the relationships between issues	○	○	○	○	○
I live in the moment	○	○	○	○	○
I plan ahead	○	○	○	○	○
When problem solving, I optimize each part of a project to produce the best result	○	○	○	○	○

Please continue to the next page

25. Please rate your general interest in the following areas.

	Not at all interested 0	1	2	3	Very interested 4
Understanding natural phenomena	○	○	○	○	○
Understanding science in everyday life	○	○	○	○	○
Explaining things with facts	○	○	○	○	○
Telling others about science concepts	○	○	○	○	○
Making scientific observations	○	○	○	○	○

26. How confident are you in your ability to do the following:

	Not at all confident 0	1	2	3	Very confident 4
Design an experiment to answer a scientific question	○	○	○	○	○
Conduct an experiment on your own	○	○	○	○	○
Interpret experimental results	○	○	○	○	○
Write a lab report/scientific paper	○	○	○	○	○
Apply science knowledge to an assignment or test	○	○	○	○	○
Explain a science topic to someone else	○	○	○	○	○
Get good grades in science	○	○	○	○	○

27. To what extent do you disagree or agree with the following statements.

	PHYSICS Strongly disagree 0	1	2	3	Strongly agree 4	MATH Strongly disagree 0	1	2	3	Strongly agree 4
I see myself as a ______ person	○	○	○	○	○	○	○	○	○	○
My parents/relatives/friends see me as a ______ person	○	○	○	○	○	○	○	○	○	○
My _____teacher sees me as a _____ person	○	○	○	○	○	○	○	○	○	○
I am interested in learning more about this subject	○	○	○	○	○	○	○	○	○	○
I am confident that I can understand this subject in class	○	○	○	○	○	○	○	○	○	○
I am confident that I can understand this subject outside of class	○	○	○	○	○	○	○	○	○	○
I enjoy learning this subject	○	○	○	○	○	○	○	○	○	○
I can do well on exams in this subject	○	○	○	○	○	○	○	○	○	○
I understand concepts I have studied in this subject	○	○	○	○	○	○	○	○	○	○
Others ask me for help in this subject	○	○	○	○	○	○	○	○	○	○
I wish I didn't have to take this subject	○	○	○	○	○	○	○	○	○	○
This subject makes me nervous	○	○	○	○	○	○	○	○	○	○
I feel invisible in classes for this subject	○	○	○	○	○	○	○	○	○	○
I can overcome setbacks in this subject	○	○	○	○	○	○	○	○	○	○

28. In your opinion, to what extent are the following associated with the field of engineering?

	Not at all 0	1	2	3	Very much so 4
Creating economic growth	○	○	○	○	○
Preserving national security	○	○	○	○	○
Improving quality of life	○	○	○	○	○
Saving lives	○	○	○	○	○
Caring for communities	○	○	○	○	○
Protecting the environment	○	○	○	○	○
Including women as participants in the field	○	○	○	○	○
Including racial and ethnic minorities as participants in the field	○	○	○	○	○
Addressing societal concerns	○	○	○	○	○
Feeling a moral obligation to other people	○	○	○	○	○

Please continue to the next page ➡

29. **To what extent do you disagree or agree with the following:**

	Strongly disagree 0	1	2	3	Strongly agree 4
Learning science will improve my career prospects	○	○	○	○	○
Science is helpful in my everyday life	○	○	○	○	○
Science has helped me see opportunities for positive change	○	○	○	○	○
Science has taught me how to take care of my health	○	○	○	○	○
Learning science has made me more critical in general	○	○	○	○	○
Science and technology make our lives healthier, easier and more comfortable	○	○	○	○	○
Technology is a solution to nearly all problems	○	○	○	○	○
I use technology more than my peers	○	○	○	○	○
Science and technology are the cause of most environmental problems	○	○	○	○	○
A country needs science and technology to become developed	○	○	○	○	○
The scientific method always leads to correct answers	○	○	○	○	○
Scientists are completely neutral and objective	○	○	○	○	○
Science and technology will provide greater opportunities for future generations	○	○	○	○	○
The benefits of new technologies greatly outweigh the risks	○	○	○	○	○
Science and technology are helping the poor	○	○	○	○	○
We should trust what scientists have to say	○	○	○	○	○
Scientific theories develop and change all the time	○	○	○	○	○

30. **How many college credit hours did you complete before starting college (e.g. AP credits, IB, dual credit)?**

○ 0 ○ 1–3 ○ 4–6 ○ 7–9 ○ 10–12 ○ 13–15 ○ >15

31. **What was the highest level of education for your parents/guardians?**

	Less than high school diploma	High school diploma/GED	Some college or associate/trade degree	Bachelor's degree	Master's degree or higher	Don't know
Male parent/guardian	○	○	○	○	○	○
Female parent/guardian	○	○	○	○	○	○

32. **Are any members of your family employed in the following professions?** *(Mark ALL that apply)*

	Mother/female guardian	Father/male guardian	Siblings	Other relative
Medical/health professional	○	○	○	○
Scientist	○	○	○	○
Engineer	○	○	○	○
Teacher	○	○	○	○
Other science, technology, or math related career	○	○	○	○
Non-science related career	○	○	○	○

33. **Which of the following people have contributed to your selection of a career path?** *(Mark ALL that apply)*

- ○ Mother/female guardian
- ○ Father/male guardian
- ○ Siblings
- ○ Other relative
- ○ Coach
- ○ Contact with someone in that major/career
- ○ School counselor
- ○ Math teacher
- ○ Biology teacher
- ○ Chemistry teacher
- ○ Physics teacher
- ○ Other teacher

34. **Have you participated in Project Lead the Way?**

○ Yes ○ No

Please continue to the next page ➡

35. Which of the following statements describes your family's interest in science and math? *(Mark ALL that apply)*

	Science	Math
This topic was a diversion or hobby	○	○
This topic was a way for me to have a better career	○	○
My family helped me with my schoolwork in this topic	○	○
My family arranged for tutoring in this topic	○	○
This topic was a series of courses that I had to pass	○	○
This topic was not a family interest	○	○

36. Which of the following math courses did you take in high school? *(Mark ALL that apply)*

- ○ Algebra I
- ○ Algebra II
- ○ Geometry
- ○ Integrated Math
- ○ Pre-Calculus
- ○ Non-AP Calculus
- ○ AP Calculus AB
- ○ AP Calculus BC
- ○ Statistics
- ○ Trigonometry/Analytical Geometry

37. For each of the following standardized tests, please indicate the highest score you earned on that test.

SAT: _____ Total _____ Math _____ Critical Reading _____ Writing ○ Don't know ○ Did not take

ACT: _____ Total _____ Math _____ English _____ Science Reasoning _____ Reading ○ Don't know ○ Did not take

38. Please answer the following for the high school courses you took. *Mark only ONE level, year, grade, and gender per row.*

HS course subject	Course level: Regular	Honors	AP	IB	Other advanced	Year taken HS	Final grade	Teacher gender
Physical Science	○	○	○	○	○	8 9 10 11 12	A+ A A- B+ B B- C D F	M F
Environmental Science	○	○	○	○	○	8 9 10 11 12	A+ A A- B+ B B- C D F	M F
Earth Science	○	○	○	○	○	8 9 10 11 12	A+ A A- B+ B B- C D F	M F
1st Biology	○	○	○	○	○	8 9 10 11 12	A+ A A- B+ B B- C D F	M F
2nd Biology	○	○	○	○	○	9 10 11 12	A+ A A- B+ B B- C D F	M F
1st Chemistry	○	○	○	○	○	9 10 11 12	A+ A A- B+ B B- C D F	M F
2nd Chemistry	○	○	○	○	○	9 10 11 12	A+ A A- B+ B B- C D F	M F
1st Physics	○	○	○	○	○	9 10 11 12	A+ A A- B+ B B- C D F	M F
2nd Physics	○	○	○	○	○	9 10 11 12	A+ A A- B+ B B- C D F	M F
Math (most advanced)	○	○	○	○	○	9 10 11 12	A+ A A- B+ B B- C D F	M F
English (most advanced)	○	○	○	○	○	9 10 11 12	A+ A A- B+ B B- C D F	M F

39. For any AP exams you took, please indicate your test score.

	AP Test Score				
AP Calculus AB	1	2	3	4	5
AP Calculus BC	1	2	3	4	5
AP Biology	1	2	3	4	5
AP Chemistry	1	2	3	4	5
AP Physics B	1	2	3	4	5
AP Physics C	1	2	3	4	5
AP Environmental Science	1	2	3	4	5

Please continue to the next page ➡

SECTION 5: DEMOGRAPHIC QUESTIONS

40. **What is your gender?** ○ Female ○ Male

41. **With which racial group(s) do you identify?** *(Mark ALL that apply)*

○ African-American or Black
○ South Asian (e.g. Indian, Pakistani, Bangladeshi, Sri Lankan, etc.)
○ Other Asian
○ American Indian or Alaskan Native
○ Caucasian or White
○ East Asian (e.g. Chinese, Korean, Japanese, etc.)
○ Native Hawaiian or Pacific Islander
○ Other ____________

42. **Please indicate if you are of Hispanic origin:** ○ Yes ○ No

43. **Which category best fits you and your parents' or guardians' background?**

	Born in United States	
Me	○ Yes	○ No
Male Parent or Guardian	○ Yes	○ No
Female Parent or Guardian	○ Yes	○ No

44. **Was English the primary spoken language in your household?** ○ Yes ○ No

45. **To help us estimate the size of the community you come from, please provide your home ZIP Code.** →

0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	4
5	5	5	5	5
6	6	6	6	6
7	7	7	7	7
8	8	8	8	8
9	9	9	9	9

46. **What year are you in college?** ○ 1st year ○ 2nd year ○ Other

47. **We would like to contact the high school science teachers of some students participating in this survey (your teachers will not know your survey responses).**
Please provide the following for your most advanced high school science courses:

Teacher's Name:

Biology	Chemistry

Physics	Math

Name of High School: ____________

City: ____________ State: ____________

We may contact some students to ask follow-up questions. All communications will be confidential and your email will NOT be disclosed to any third party.

Your email address: ____________

Note: By completing this survey, you attest that you are 18 years of age or older and that you agree to participate in this research study.

You have reached the end of the survey.
Thank you for your time.
It is our goal that many science educators will benefit from the insights you have provided!

DO NOT WRITE IN THIS AREA

SERIAL #

10

Appendix B: A Study of How Pre-College Informal Activities Influence Female Participation in STEM Careers Survey (Chapter 3)

Harvard-Smithsonian Center for Astrophysics

Science Education Department

Survey of Students in Introductory College Classes

Researchers at the Harvard-Smithsonian Center for Astrophysics are interested in how your prior experiences, especially with out-of-school-time science activities, are shaping your career plans. By filling out this questionnaire you will help us find ways to improve science education for future students. Make your best estimate for each item and answer as many questions as possible. Your participation is, of course, voluntary. <u>If you are under the age of 18, you may not participate in this study</u>. Thank you for your help.

This survey should take about 15–20 minutes to complete.

Confidentiality: This survey does not ask you for your name. <u>Your anonymity is guaranteed</u>. Any reports, published or unpublished, arising from this study, will include only averaged data of large groups.

Thank you for your time!

Use a No. 2 pencil or blue or black pen only.

CORRECT MARK ●   INCORRECT MARKS ✓ ✗

This project is funded by the National Science Foundation, grant number 1612375: *How Pre-College Informal Activities Influence Female Participation in STEM Careers*. The lead researcher for this study is Dr. Philip M. Sadler, who can be reached at 617-496-4709 or by email at: psadler@cfa.harvard.edu.

DO NOT WRITE IN THIS AREA

SERIAL #

3/8" PERF

NOTE: In this questionnaire, STEM stands for "Science, Technology, Engineering, Mathematics"

ABOUT YOUR CAREER PLAN DEVELOPMENT:

1. Which of the following describes what you want(ed) to be at the beginning of middle school, in high school (beginning and end), and at the beginning of college: *Mark all that apply. Leave blank those that do not apply.*

	Beginning of Middle School	Beginning of High School	End of High School	Beginning of first semester of College
Medical doctor (e.g., physician, dentist, vet.)				
Health professional (e.g., social worker, nurse, pharmacist)				
Astronomer				
Biologist				
Chemist				
Earth/Environmental scientist				
Physicist				
Other scientist				
Engineer				
Computer scientist/Programmer/IT Specialist				
Mathematician/Statistician				
STEM teacher				
Other teacher				
Anthropologist/Archaeologist				
Social scientist (e.g., psychologist, sociologist)				
Humanities professional (e.g., historian, language specialist, writer, philosopher)				
Visual artist (e.g., painter, sculptor, architect, computer artist/ animator)				
Performing artist (e.g., actor, musician, dancer)				
Business person (e.g., entrepreneur, manager)				
Lawyer				
Politician				
Athlete/Coach				
Military personnel				
Other non-STEM related career				

2. Rate the following factors in terms of their importance for your future career satisfaction:

	Not at all important 0	1	2	3	4	5 Extremely important
Making money	0	1	2	3	4	5
Becoming well known	0	1	2	3	4	5
Helping other people	0	1	2	3	4	5
Having others working under my supervision	0	1	2	3	4	5
Having job security	0	1	2	3	4	5
Working with people rather than objects	0	1	2	3	4	5
Inventing new things	0	1	2	3	4	5
Developing new knowledge and skills	0	1	2	3	4	5
Having lots of family time	0	1	2	3	4	5
Having lots of time for myself/friends	0	1	2	3	4	5
Making my own decisions	0	1	2	3	4	5
Having an easy job	0	1	2	3	4	5
Having an exciting job	0	1	2	3	4	5
Making use of my talents/abilities	0	1	2	3	4	5
Working in an area with lots of job opportunities	0	1	2	3	4	5
Having a creative job	0	1	2	3	4	5

ABOUT YOUR EARLY SCHOOL SCIENCE AND MATH EXPERIENCES:

3. How would you rate your science experiences in elementary grades (K-4)?

Very memorable in a negative way 0	1	2	3	4	5 Very memorable in a positive way
0	1	2	3	4	5

4. What was your average grade in middle school (5-8)? *Letter grades include intermediate grades (e.g., A-, C+).*

	A	B	C	D	F
English/Language Arts	A	B	C	D	F
Mathematics	A	B	C	D	F
Science	A	B	C	D	F

NEXT →

DO NOT WRITE IN THIS AREA

SERIAL #

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NOTE: In this questionnaire, STEM stands for "Science, Technology, Engineering, Mathematics"

5. At the end of middle school, how interested were you in:

	Not at all interested 0	1	2	3	4	5 Extremely interested
Science	⓪	①	②	③	④	⑤
Mathematics	⓪	①	②	③	④	⑤
Engineering	⓪	①	②	③	④	⑤
Computing	⓪	①	②	③	④	⑤

ABOUT YOUR HIGH SCHOOL BACKGROUND:

6. What type of school did you go to? *Mark all that apply.*

- ○ Public
- ○ Private/Independent
- ○ Public Charter
- ○ Private Religious
- ○ Magnet School
- ○ Vocational
- ○ International Baccalaureate
- ○ Single-sex
- ○ Outside of US
- ○ Home Schooled

7. To help us estimate the size of the community you come from, please provide your home ZIP Code when you went to high school and bubble in the corresponding numbers.

ZIP CODE				
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	4
5	5	5	5	5
6	6	6	6	6
7	7	7	7	7
8	8	8	8	8
9	9	9	9	9

8. What grade did you get in your last high school English course? *Letter grades include intermediate grades (e.g., A-, C+).*

○ A ○ B ○ C ○ D ○ F

9. Which of the following mathematics courses did you take in high school? *Mark all that apply.*

- ○ Trig./Analytic Geometry
- ○ Statistics
- ○ Pre-Calculus
- ○ AP Statistics
- ○ Calculus
- ○ Integrated Math
- ○ AP Calculus AB
- ○ AP Calculus BC

10. For the most advanced mathematics course you took, what was your final grade? *Letter grades include intermediate grades (e.g., A-, C+).*

○ A ○ B ○ C ○ D ○ F

PROOF

11. For each of the following standardized tests, please indicate the score you earned on each subtest taken by marking the appropriate numbers.

SAT Score	SAT Exam-pre March 2016: Math Subtest	SAT Exam-pre March 2016: Writing Subtest	SAT Exam-pre March 2016: Critical Reading Subtest	New SAT: Reading and Writing Subtest	New SAT: Math Subtest	ACT Score	ACT Exam: Math Subtest	ACT Exam: English Subtest	ACT Exam: Science Subtest	ACT Exam: Reading Subtest
200–300	○	○	○	○	○	1–11	○	○	○	○
310–400	○	○	○	○	○	12–15	○	○	○	○
410–500	○	○	○	○	○	16–20	○	○	○	○
510–600	○	○	○	○	○	21–25	○	○	○	○
610–700	○	○	○	○	○	26–30	○	○	○	○
710–800	○	○	○	○	○	31–36	○	○	○	○

12. For the following high school STEM courses you took, please indicate the level of the course. *Mark only ONE course level per row.*

HS Course Subject	Course Level: Regular	Honors	AP	IB	Dual enrollment
Phyiscal Science	○	○	○	○	○
1st Biology course	○	○	○	○	○
2nd Biology course	○	○	○	○	○
1st Chemistry course	○	○	○	○	○
2nd Chemistry course	○	○	○	○	○
1st Physics course	○	○	○	○	○
2nd Physics course	○	○	○	○	○
Engineering	○	○	○	○	○
Computer Science	○	○	○	○	○

3/8" PERF

NOTE: In this questionnaire, STEM stands for "Science, Technology, Engineering, Mathematics"

13. At the end of high school, how interested were you in:

	Not at all interested 0	1	2	3	4	5 Extremely interested
Science	0	1	2	3	4	5
Mathematics	0	1	2	3	4	5
Engineering	0	1	2	3	4	5
Computing	0	1	2	3	4	5

ABOUT YOUR STEM-RELATED INTERESTS:

14. Which of the following experiences did you have while growing up? *Mark all that apply. Leave blank those that you did not have.*

	If you had these experiences, please mark how often and during which grades you participated					
	K-4		5-8		9-12	
	Sometimes	Often	Sometimes	Often	Sometimes	Often
Using tools to tinker with/take apart **mechanical** devices (e.g., bicycle, watch, door lock)						
Using tools to tinker with/take apart **electrical** devices (e.g., hair dryer, hand mixer, TV, computer)						
Baking/cooking/kitchen chemistry						
Using science equipment (e.g., microscope, telescope)						
Using STEM toys/kits (e.g., building/construction sets, circuit boards, model rockets, science kits)						
Playing strategy board games/logic games or puzzles						
	Sometimes	Often	Sometimes	Often	Sometimes	Often
Reading **non-fiction** science (e.g., news, books, magazines, journals - hardcopy or online)						
Reading science **fiction** (hardcopy or online)						
Watching STEM-related TV programs or movies (documentaries, dramas, sci-fi.)						
Watching online STEM-related videos (e.g., YouTube)						
Playing STEM computer/video games						
Following STEM on social media						
Using STEM apps (eg., SkyView, BrainPOP, Touch Surgery)						
Writing about STEM, including creating online blogs/podcasts/videos						
Writing computer programs/games/apps or designing web pages						
	Sometimes	Often	Sometimes	Often	Sometimes	Often
Taking care of/raising/training an animal						
Indoor/outdoor gardening						
Observing/documenting animals (e.g., bird-watching)						
Collecting things in nature (e.g., rocks, seashells)						
Observing or studying stars and other astronomical objects						
Observing clouds or weather patterns						
Taking/editing photographs or videos of nature						
Exploring nature while walking/hiking/ camping/snorkeling/ geocaching, etc.						
Collecting/analyzing data for scientists (online, with apps, or in person, e.g., Zooniverse)						

NEXT →

NOTE: In this questionnaire, STEM stands for "Science, Technology, Engineering, Mathematics"

15. Did you participate in any of the following STEM programs/activities during your middle or high school years? ***Mark all that apply. Leave blank those that do not apply.***

	If you participated in any of these activities, please mark how often and in which grades you participated				This activity increased my interest in STEM
	5-8		9-12		
	Sometimes	Often	Sometimes	Often	Mark if yes
STEM-related extracurricular clubs/teams at school	○	○	○	○	○
STEM-related clubs/teams outside of school	○	○	○	○	○
Group organization (e.g., Girl Scouts, Boy Scouts, 4H)	○	○	○	○	○
Maker/DIY STEM activities/events	○	○	○	○	○
Overnight STEM programs (at museums, science centers, etc.)	○	○	○	○	○
STEM Cafes (eat, drink, chat about STEM with professionals)	○	○	○	○	○
STEM-related vacation or summer camps	○	○	○	○	○
STEM-related programs that collect/analyze data for scientists (e.g., citizen science)	○	○	○	○	○
	Sometimes	Often	Sometimes	Often	Mark if yes
STEM-related lectures or talks (online or in person)	○	○	○	○	○
STEM-related courses/workshops outside of school (online or in person)	○	○	○	○	○
STEM-related leadership conferences	○	○	○	○	○
Science fairs	○	○	○	○	○
Robotics competitions	○	○	○	○	○
Engineering competitions	○	○	○	○	○
Computing/IT competitions	○	○	○	○	○
STEM-related academic/research summer programs	○	○	○	○	○
	Sometimes	Often	Sometimes	Often	Mark if yes
STEM-related career days	○	○	○	○	○
Tours of STEM-related settings (e.g., hospital, vet's office, lab)	○	○	○	○	○
STEM-related job-shadowing	○	○	○	○	○
STEM-related internships	○	○	○	○	○
Work/Volunteer in a STEM-related setting (e.g., hospital, vet's office, lab, camp, museum, zoo)	○	○	○	○	○

16. If you participated in STEM programs/activities <u>outside of school</u>, what was your experience with the following opportunities:

	I experienced this STEM opportunity	This opportunity increased my interest in STEM	This opportunity showed the real-life relevance of STEM
	Mark if yes	Mark if yes	Mark if yes
Interacting with a STEM mentor	○	○	○
Interacting with a STEM role model	○	○	○
Interacting with someone who works in a STEM career	○	○	○
Working with older STEM students (college students)	○	○	○
Taking on a leadership role	○	○	○
Mentoring/tutoring younger students in STEM	○	○	○
	Mark if yes	Mark if yes	Mark if yes
Participating in hands-on STEM activities	○	○	○
Participating in programs with art and/or design connections (STEAM)	○	○	○
Working on real world STEM issues/problems	○	○	○
Using STEM equipment to collect data	○	○	○
Building/constructing STEM models	○	○	○
Designing and carrying out my own STEM project	○	○	○
Working with others on a team	○	○	○
Presenting STEM data/information to others (e.g., poster, paper, oral presentation)	○	○	○
Learning about STEM careers	○	○	○

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17. Did you attend any single sex STEM programs?
○ yes ○ no

18. Did you attend any STEM programs designed specifically for underrepresented minorities?
○ yes ○ no

19. If you had someone you consider a STEM role model, were they reflective of your *(mark all that apply)*:
○ gender identity ○ ethnic identity ○ racial identity ○ not reflective of my gender, ethnic , or racial identity

20. If you did NOT attend any STEM programs/activities outside of school, please indicate why. *Mark all that apply.*
○ I didn't know STEM opportunities were available in my area
○ I looked, but there were no STEM opportunities available in my area
○ STEM opportunities were available but I didn't have the time (other commitments: work/home/other activities) to attend
○ STEM opportunities were available but I didn't have the resources (transportation/finances) to attend
○ STEM opportunities were available but I was not interested in the specific topics offered
○ STEM opportunities were available but I was not interested in STEM
○ STEM opportunities were available but I didn't feel welcome/comfortable attending
○ Other: ________________

21. Some people say their interest (or lack of interest) in STEM is the result of many events. Others say there was one defining event (seeing something, hearing something, learning something, meeting someone, etc.). Which best describes your experiences?
○ Many events ○ One single event

If a single event, when did it occur: ○ K-4 ○ 5-8 ○ 9-12

If a single event, where did it occur: ○ in school ○ outside of school

22. To what extent do you disagree or agree with the following statements:

No, Not at all	0	1	2	3	4	5 Yes, Very much
Topics in STEM excite my curiosity	⓪	①	②	③	④	⑤
I enjoy learning about STEM	⓪	①	②	③	④	⑤
I like to know what is going on in STEM	⓪	①	②	③	④	⑤
I feel confident in my ability to learn STEM	⓪	①	②	③	④	⑤
Others ask me for help in STEM	⓪	①	②	③	④	⑤
I can do well on tests/exams in STEM	⓪	①	②	③	④	⑤
I understand concepts I have studied in STEM	⓪	①	②	③	④	⑤
I can overcome setbacks in learning STEM	⓪	①	②	③	④	⑤
I am interested in learning more about STEM	⓪	①	②	③	④	⑤
I see myself as a STEM person	⓪	①	②	③	④	⑤
My family sees me as a STEM person	⓪	①	②	③	④	⑤
My friends/classmates see me as a STEM person	⓪	①	②	③	④	⑤
My classroom STEM teachers see me as a STEM person	⓪	①	②	③	④	⑤
My out-of-school teachers see me as a STEM person	⓪	①	②	③	④	⑤
I am aware of many types of STEM-related careers	⓪	①	②	③	④	⑤
I am aware of the skills STEM professionals use	⓪	①	②	③	④	⑤
I feel I belong in the STEM community	⓪	①	②	③	④	⑤

ABOUT YOURSELF AND YOUR FAMILY:

23. Gender? ○ Male ○ Female ○ Other: ________________

24. Are you of Hispanic origin? ○ yes ○ no

25. What is your race? *(For multi-racial, mark all that apply.)*
○ Black ○ White ○ Asian or Pacific Islander ○ American Indian or Alaskan Native ○ Other: ________________

26. Was English the primary spoken language in your household? ○ yes ○ no

27. What year are you in college? ○ Freshman ○ Sophomore ○ Other: ________________

NEXT →

NOTE: In this questionnaire, STEM stands for "Science, Technology, Engineering, Mathematics"

28. What was the highest level of education for your parents/guardians?

	Male	Female	Less than High School Diploma	High School Diploma/GED	Some College/ Associate Degree	Bachelor's Degree	Master's Degree or higher	Not applicable
Parent/guardian #1	○	○	○	○	○	○	○	○
Parent/guardian #2	○	○	○	○	○	○	○	○

29. Which category best fits you and your parents' or guardians' background?

	Born in United States		
You	○ Yes	○ No	
Parent or Guardian #1	○ Yes	○ No	○ Not applicable or Don't know
Parent or Guardian #2	○ Yes	○ No	○ Not applicable or Don't know

30. Which of the following statements describes your family's interest in, and attitudes toward STEM?
Mark all that apply.

○ STEM is involved in career of parent #1.
○ STEM is involved in a sibling's career.
○ STEM is considered a diversion or hobby.
○ STEM is not a family interest.
○ Someone could help me with STEM homework.
○ My family arranged my attendance in out of school STEM programs.
○ STEM is involved in career of parent #2.
○ STEM is involved in another relative's career.
○ STEM is a way for people to have a better career.
○ STEM was a series of courses that I had to pass.
○ My family supported my attending STEM programs/activities.

31. How often have you done the following?

	With family				With friends			
	Not at all			Very often	Not at all			Very often
Talk about STEM	○	○	○	○	○	○	○	○
Participate in STEM activities	○	○	○	○	○	○	○	○
Visit science centers, museums, nature centers, etc.	○	○	○	○	○	○	○	○
Attend STEM event/programs	○	○	○	○	○	○	○	○

32. Who encouraged you to select a *STEM* career path? *Mark all that apply.*

○ No One
○ Sibling
○ Elementary School Teacher
○ School Counselor
○ Other: ____________________
○ Parent/Guardian #1
○ Other relative
○ Middle School Teacher
○ Out-of-School Teacher
○ Parent/Guardian #2
○ Friend
○ High School Teacher
○ Mentor or Role Model

33. Who encouraged you to select a *non-STEM* career path? *Mark all that apply.*

○ No One
○ Sibling
○ Elementary School Teacher
○ School Counselor
○ Other: ____________________
○ Parent/Guardian #1
○ Other relative
○ Middle School Teacher
○ Out-of-School Teacher
○ Parent/Guardian #2
○ Friend
○ High School Teacher
○ Mentor or Role Model

You have reached the end of the survey. Thank you very much for your time!

Appendix C: Abbreviated version of A Study of How Pre-College Informal Activities Influence Female Participation in STEM Careers Survey for interviewing (Chapter 4)

Researchers at the Harvard-Smithsonian Center for Astrophysics and Florida International University are interested in how your prior experiences, are shaping your identity and career plans. By filling out this questionnaire you

may help us find ways to improve science education for future students. Make your best estimate for each item and answer as many questions as possible. Your participation is, of course, voluntary. If you are under the age of 18, you may not participate in this study. Thank you for your help.

This survey should take about

10 minutes to complete.

Confidentiality: Any reports, published or unpublished, arising from this study, will include only averaged data of large groups.

Thank you for your time!

ABOUT YOUR CAREER PLAN DEVELOPMENT:

1. Which of the following describes what you want to be. ***Mark all that apply. Leave blank those that do not apply.***

Medical doctor (e.g., physician, dentist, vet.)	O
Health professional (e.g., social worker, nurse, pharmacist)	O
Astronomer	O
Biologist	O
Chemist	O
Earth/Environmental scientist	O
Physicist	O
Other scientist	O
Engineer	O
Computer scientist/Programmer/IT Specialist	O
Mathematician/Statistician	O
STEM teacher	O
Social scientist (e.g., psychologist, sociologist)	O
Non-STEM related career	O

2. How likely are you to select a Science, Technology, Engineering or Math (STEM) career?

No, Not likely at all — Yes, Very likely

0	1	2	3	4	5
O	O	O	O	O	O

ABOUT YOUR EARLY SCHOOL SCIENCE AND MATH EXPERIENCES:

3. How would you rate your science experiences in elementary grades (K-4)?

Very memorable in a <u>negative</u> way — Very memorable in a <u>positive</u> way

0	1	2	3	4	5
O	O	O	O	O	O

4. What was your average grade in middle school (5-8)? ***Letter grades include intermediate grades (e.g., A-, C+).***

	A	B	C	D	F
English/Language Arts	O	O	O	O	O
Math	O	O	O	O	O
Science	O	O	O	O	O

5. At the end of middle school, how interested were you in:

	Not interested at all					Extremely Interested
	0	1	2	3	4	5

Science	O	O	O	O	O	O
Mathematics	O	O	O	O	O	O
Engineering	O	O	O	O	O	O
Computing	O	O	O	O	O	O

ABOUT YOUR HIGH SCHOOL BACKGROUND:

6. Which of the following math courses did you take in high school? ***Mark all that apply.***

O Trig./Analytic Geometry O Pre-Calculus O Calculus O AP Calculus AB
O AP Calculus BC O Statistics O AP Statistics O Integrated Math

7. For the most advanced math course you took what was your final grade? ***Letter grades include intermediate grades (e.g., A-, C+).***

O A O B O C O D O F

8. For the following standardized tests, please indicate the score you earned on the subtest taken by marking the appropriate numbers.

	SAT Exam – pre March 2016	**New SAT**		**ACT Exam**	
SAT Score	Math Subtest	Math Subtest		**ACT Score**	Math Subtest
200-300	O	O		1-11	O
310-400	O	O		12-15	O
410-500	O	O		16-20	O
510-600	O	O		21-25	O
610-700	O	O		26-30	O
710-800	O	O		31-36	O

9. At the end of high school, how interested were you in:

	Not interested at all					Extremely interested
	0	1	2	3	4	5
Science	O	O	O	O	O	O
Mathematics	O	O	O	O	O	O
Engineering	O	O	O	O	O	O
Computing	O	O	O	O	O	O

ABOUT YOUR STEM-RELATED INTERESTS:

10. Which of the following experiences did you have during your K-4 elementary years? ***Mark all that apply. Leave blank those that do not apply.***

	K-4
Using tools to tinker with/take apart **mechanical** devices (e.g., bicycle, watch, door lock)	O
Baking/cooking/kitchen chemistry	O
Using STEM toys/kits (e.g. building/construction sets, circuit boards, model rockets, science kits)	O
Playing strategy board games/logic games or puzzles	O

Reading <u>non-fiction</u> science (e.g., news, books, magazines, journals - hardcopy or online)	O
Watching STEM-related TV programs or movies (documentaries, dramas, scifi.)	O
Playing STEM computer/video games	O
Writing about STEM, including creating online blogs/podcasts/videos	O
Indoor/outdoor gardening	O
Observing or studying stars and other astronomical objects	O
Observing clouds or weather patterns	O

11. To what extent do you disagree or agree with the following statements:

	No, Not at all					Yes, Very much
	0	1	2	3	4	5
Topics in STEM excite my curiosity	O	O	O	O	O	O
I enjoy learning about STEM	O	O	O	O	O	O
I like to know what is going on in STEM	O	O	O	O	O	O
I feel confident in my ability to learn STEM	O	O	O	O	O	O
Others ask me for help in STEM	O	O	O	O	O	O
I can do well on tests/exams in STEM	O	O	O	O	O	O
I understand concepts I have studied in STEM	O	O	O	O	O	O
I can overcome setbacks in learning STEM	O	O	O	O	O	O
I am interested in learning more about STEM	O	O	O	O	O	O
My family sees me as a STEM person	O	O	O	O	O	O
My friends/classmates see me as a STEM person	O	O	O	O	O	O
My classroom STEM teachers see me as a STEM person	O	O	O	O	O	O
My out-of-school teachers see me as a STEM person	O	O	O	O	O	O

ABOUT YOURSELF AND YOUR FAMILY:

12. Gender? O Male O Female O Other: ____________________

13. What is your race? ***(For multi-racial, mark all that apply.)***

O Black O White O Asian or Pacific Islander O American Indian or Alaskan Native
Other:___________________

14. Which of the following statements describe your family's interest in, and attitudes toward STEM? ***Mark all that apply. Leave blank those that do not apply.***

O STEM is involved in career of male parent
O STEM is involved in career of female parent
O STEM is involved in a sibling's career.
O STEM is involved in another relative's career.
O STEM is NOT a family interest.

15. If you plan on pursuing a STEM career, who encouraged you to select a *STEM* career path? ***Mark all that apply. Leave blank those that do not apply.***

O Male Parent/Guardian
O Female Parent/Guardian
O Elementary School Teacher
Other: _________________________

We would like to briefly interview select students about their early STEM experiences. If you are interested in being interviewed, please provide your name and contact information. We will provide a gift card for your participation.

Name: ____
Email Address: ____

Appendix D: Sample email to students who were interested in participating in the qualitative follow-up study

Dear _____

You recently completed a survey in your fall ____ class about your early STEM experiences and were willing to be interviewed. We are interested in interviewing you about your experiences and the effect they had on your choice of a STEM career. You will receive a ___ Starbucks gift card for your participation, which will include a brief 30-minute interview (approximately) about your familial STEM occupations and early STEM experiences. This interview is voluntary and can be conducted in person or over the phone at your convenience. Your responses will be recorded (audio), transcribed and sent to you within two weeks of the interview to give you an opportunity to check and adjust your responses.

As a participant in this study, your information will be kept confidential. There are no known risks associated with this research. If you are under the age of 18, you may not participate in this study.

Please let me know what date and time might be most convenient to schedule your interview. We appreciate your time and willingness to participate in this study.

Sincerely,

Susie M. Cohen
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FIU IRB Approval #: IRB-17-0103-AM01

Appendix E: Codebook from qualitative study

- **Familial Occupations~Identity~Career Choice**
  - **Other Relative in STEM**
    - **Quorum OR**
      - Relatives Overseas
    - **Mentorship OR**
      - Resources
      - Verbal Encouragement
- **Encouragement~Identity~Career Choice**
  - **Encouragement from father**
    - **STEM in Daily Life**
      - Going to Work with father
      - Fixing things around house
    - **STEM Resources - father**
      - Intangible
      - Tangible
    - **Continuous Engagement - father**
      - Advice
      - Fixing things
      - Continuous Homework Help
    - Homework Assistance from Father
    - Pressure Free Environment - father (and mother)
    - Verbal Praise/Encouragement - father
  - **Encouragement from mother**
    - **STEM Resources**
      - Tangible2
      - Camps/Trips
    - **Verbal Praise/ Encouragement - mother**
      - Capable
      - General forms of encouragement
    - **Role Model**
      - Going to Work
      - Career Talk
    - **Continous Engagement - mother**
      - Mentorship
      - Advice2
    - Homework Assistance - mother
    - STEM Learning talks/Career Conversations - mother
- **Elementary School Teacher Encouragement**
  - Verbal Praise/Encouragement - EST
  - Participation in STEM Activities - EST
  - Continuous Engagement - EST
  - Engaging Teaching Style - EST
- **Early STEM experiences**
  - **Toys/ Kits**
    - Hands-on Experience - toys/kits
    - Heightened Emotions - toys/kits
    - Influence from Other People - toys/kits
    - Continuous Engagement - toys/kits
  - **STEM TV**
    - Heightened Emotions - tv
    - Influence from Other People - tv
    - Cognitive Engagement - tv
    - Future Connections - tv
    - Continuous Engagement - tv
  - **Playing STEM computer/video**
    - Heightened Emotions - compture/video
    - Agency - computer/video
    - Influence from Other People - compture/video
    - Continuous Engagement - computer/video
    - Cognitive Engagement - computer/video
    - Reward - computer/video
  - **Stars and astonomical objects**
    - Influence from Other People - stars
    - Heightened Emotions - stars
    - **Hands-on Experience - stars**
      - Use of telescope
      - Excitement with telescope
  - **Cooking and Kitchen chemistry**
    - Cooking with mother
    - Hands-on Experience - cooking
    - Unrelated to STEM - cooking
    - Continuous Engagement - cooking
  - **Writing about STEM**
    - School Assignment
    - Absence of Online - writing

VITA

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2008-2014	Teacher/Science Coordinator Wellington Christian School Wellington, Florida
2015-2019	Graduate/Teaching Assistant Florida International University Miami, Florida
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PUBLICATIONS AND PRESENTATIONS

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