2019

The influence of a female-centered figured world on the STEM identities of young girls

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The influence of a female-centered figured world on the STEM identities of young girls

by

Ashley Reagan-Meyer Delaney

A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Curriculum and Instruction

Program of Study Committee:
Christa Jackson, Major Professor
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The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this dissertation. The Graduate College will ensure this dissertation is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University
Ames, Iowa
2019

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DEDICATION

For my family.

To my husband and best friend, Brett.
Your love and support are the greatest blessings of my life. We did this together.

To my children.
You are my inspiration and the light of my life. Be kind. Ask good questions. Dream big.
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ACKNOWLEDGEMENTS

Firstly, thank you to my mother, Pat Reagan, for being my very first teacher, sounding board, trusted advisor, and loudest cheerleader. You have taught me more than any degree could ever show. I come from a long line of tenacious, passionate women who have molded me into who I am today. I would not be who or where I am without your selfless support and nurture. Thank you for feeding my fire instead of suffocating my spark.

My deepest appreciation to my committee chair, Dr. Christa Jackson, who is equal parts brilliance, grace, power, enthusiasm, and love. She persistently and convincingly shared her excitement for research, teaching, and outreach. Her guidance and patience helped make this dissertation possible. Dr. Jackson is my academic mother, and I am so very grateful she adopted me. I am honored to call her a dear friend and my chosen family.

In addition, a thank you to my graduate and research colleagues. I have had the privilege to spend the last four years working alongside some of the best. I particular note of thanks to Kari Jurgenson who helped with so much during my dissertating process. She was the calm to my crazy and the safe to my wild as we pursued our doctorates side-by-side. She is one of the most genuine, hard-working colleagues. I will deeply miss sharing an office with her and getting her input on all thing academic and life. Another special thank you to Dr. Margaret Mohr-Schroeder and Dr. Mollie Appelgate who took me under their wings along with Dr. Jackson. They have listened, advised, consoled, and encouraged me over the last four years as if I was one of their own.
I would also like to thank my committee members: Dr. Kristina Tank, Dr. Cassandra Dorius, and Dr. Douglas Wieczorek. The time and energy they invested in my development were critical to the completion of this dissertation. Thank you for being a part of my journey.

My village is large, and it is strong. My sister, Kipley, and her family cheered me on from afar, modeled STEM activities, and let our girls have fun on the lake while I worked at the cabin. I do not say it enough, but my sister is one of the important people in my life. She has taught me kindness, compassion, and dedication. I am better because she is my big sister. Kelly, my best friend of 35 years, is the second sister God always knew I needed. She sent text messages of love and prayers at *just the right time* almost every time. The moment when I needed an extra boost she somehow knew it and made sure I felt her support. My family by marriage, Laura, Steve, Nana Judy and Papa Larry, GG Alice and Dale; Marcus and Megan, and Joel and Andrea, all stepped up more than once to make sure our family could function while I worked and studied. We all love you to the moon. My neighbors and friends let me vent, shared in my accomplishments, and encouraged me when I needed it most. These people are my village, and I could not be more grateful for all of them. It does indeed take a village to raise a child. Turns out, it also takes a village to finish a Ph.D. Thank you to all of you.

Finally, to the young girls and their families who participated in this study, thank you for making this all possible. I will forever be indebted to the parents for giving of your time, thoughts, and energy. You made time for you and your child to participate in this study and fulfilling one of my dreams of becoming a doctor. Each of you holds a
special place in my heart. You are each a part of my story. I can only hope I am a part of yours and have inspired you in return. Go and move mountains, girls!
ABSTRACT

Children ages five to eight are in a pivotal period for building conceptual understandings of their identities, especially in relation to gender (Glenn, 1999). Thus, the early elementary is a prime time to influence children’s STEM identities. Children’s sense of belonging, self-efficacy, and interest contribute to their learning of STEM content (Bell, Lewenstein, Shouse, & Feder, 2009). Developing a positive STEM identity has long-term implications for females entering STEM fields.

I used the Figured Worlds framework (Holland, Lachicotte, Skinner, and Cain, 1998) to conceptualize STEM identity development and study the phenomenon in young females. In particular, I investigated two cases of White females, which were defined by participation in a female-centered figured world, the STEM Princess (STEMP) case compared to those who did not participate, the Business as Usual (BAU) case. The female-centered figured world of the STEM Princess used the ultra-feminity of popular culture princesses to peak the interest of young girls in STEM and engage them in STEM experiences rich with role models and activities.

This collective case study sought to understand the complex process of STEM identity development (Stake, 1995). Children’s engagement, or lack thereof, in the STEM Princess figured world permitted the investigation of the STEM identities children constructed (Merriam, 2009). STEM identity development was influenced by participants’ conceptions of gender, conceptions of STEM and the STEM community, sense of belonging, self-efficacy, and interest in STEM. Other figured worlds such as home and school also influenced participants’ STEM identities. The greatest development in STEM identities occurred with participation in STEM across figured
worlds. Continuous exposure to the STEM Princess figured world resulted in the more rapid, dramatic growth in the STEM identities of the STEMP case when compared to the BAU case. Implications to promote STEM identity development in young children, specifically females, are discussed.
CHAPTER 1: INTRODUCTION

Children ages five to eight are in a pivotal period for building conceptual understandings of how gender is an important element of their identities (Glenn, 1999). Thus, the early elementary years are a prime time to influence children’s STEM identities. Developing a positive STEM identity has long-term implications on how to engage, motivate, and inspire females to enter into STEM fields. Research indicates gender stereotypes and biases are flexible and can evolve over time (Devine, 1989). Similarly, identities, especially those of children, are continuously forming and reforming as they engage in new worlds that broaden their exposure to beliefs, practices, and people (Holland, Lachicotte, Skinner & Cain, 1998). This indicates purposeful positioning of children into STEM figured worlds may have the power to change their stereotypes related to gender and STEM influencing the development of their STEM identities, even at a young age.

Children’s sense of belonging, self-efficacy, and agency contribute to their success in learning and retaining STEM content (Bell, Lewenstein, Shouse, & Feder, 2009). While personal interest and identities are key components in inspiring students to pursue careers and paths in STEM learning, the field must also consider the systemic biases contributing to persistent underrepresentation of females in STEM fields. Addressing masculine stereotypes and bias prevalent in STEM to provide a counter narrative for females has the potential to transform their conceptions of STEM and (re)conceptualize their identities (Chacon & Soto-Johnson, 2003). Stereotypes and
representation of gender are particularly impactful on the identity development of females (Orenstein, 2012). Shaping experiences where children can engage with members of the STEM community that look like them increase opportunities for females to develop STEM identities. Studies spanning K-12 settings indicate the formal STEM education setting is not inclusive of females (e.g. Archer et al., 2010; Archer et al., 2013; Bachman, Hebl, Martinez & Rittmayer, 2009). The limited opportunities for females to engage in STEM is also related to how formal education has adopted STEM content and curriculum.

Science, technology, engineering, and mathematics are separated into four distinct disciplines in formal education. However, many careers centered in these fields require individuals to use information from each discipline by seamlessly integrating the knowledge and skills to complete a task. This requires the field of education to think about science, technology, engineering, and mathematics as a synergy of disciplines that transcend the compartmentalized knowledge and skills from each. STEM education is more than the four silos of science, technology, engineering and mathematics (Bybee, 2010a). Merrill and Daugherty (2009) define STEM as an integrated discipline. STEM is a “standards-based, meta-discipline… where discipline specific content is not divided, but addressed and treated as one dynamic, fluid study” (p. 49). The careers that will approach solving the complex problems that face the future generation require considering STEM as a meta-discipline that emphasizes innovative thinking (Zollman, 2012).
The emerging global issues and evolving demands of business are why nine out of the ten fastest growing occupations require STEM education (Hill, Corbett, & St. Rose, 2010). Increasing student interest in STEM disciplines is the catalyst for meeting the economic demands and changing positions students will fill (Elam, Donham, & Soloman, 2012; Muzzatti & Agnoli, 2007; National Alliance for Partnerships in Equity (NAPE), 2009). However, the current demographic make-up of our schools does not match the demographics of our STEM classrooms and STEM professionals (NAPE, 2009). A national movement to increase the number of students interested in STEM and pursuing STEM careers will only be realized if the potential of all students is developed.

The current gaps in STEM fields could be filled by traditionally underrepresented groups including women and minorities. However, current data indicates these groups are not as attracted to STEM as their White, male counterparts (NAPE, 2009). Females, in particular, express feeling inadequate and lacking a sense of belonging, resulting in an avoidance of STEM education and related careers (Wang, 2013). The interest and achievement gaps among African Americans, Hispanics, and females in the STEM fields are alarming and limiting for pursuing STEM-related careers (PCAST, 2010). Flores (2007) argues the interest and achievement gaps are merely outcomes from the opportunity gap facing underrepresented groups starting at an early age. Early childhood is a pivotal time for opening the door to opportunities that broaden children’s interest by increasing their exposure to experiences, content, and role models (Carter & Welner, 2013).
Researchers indicate exposure to a variety of STEM opportunities and role models will have long term effects on individuals’ identities and the overall STEM education community (Wai, Lubinski, Benbow, & Steiger, 2010). A relatively few number of STEM role models for underrepresented populations perpetuates exclusive perception of the STEM community. Interactions with a diverse body of role models can help to correct misconceptions about the STEM community (Muzzatti & Agnoli, 2007) and increase interest in and identification with STEM as a future career (NAPE, 2009). This is especially true for females. Connecting female students to female role models in STEM is shown to remove or lessen aversion to STEM, including negative gender stereotypes (Rivardo, Rhodes, & Klein, 2008), and helps with constructing positive STEM identities (Chacon & Soto-Johnson, 2003).

Studies have shown that students who have an increased interest in science, mathematics, and engineering early are more likely to pursue a STEM-related career (Afterschool Alliance Report, 2011). However, before many students exit elementary school, they do not include STEM as a part of their identity (PCAST, 2010). Children perceive STEM as useful, but complex and intimidating (Christensen, Knezek & Tyler-Wood, 2014). Furthermore, by middle school most children have lost interest in pursuing STEM believing it is elitist and not for them (Maltese & Tai, 2011; Wyss, Heulskamp & Siebert, 2012). Many STEM programs focused on traditionally underrepresented groups target adolescents as a pivotal period of identity development and a time when students openly depart from STEM fields (PCAST, 2010). In essence, the programs are a reaction to the adolescents expressing their already-formed conceptions and identities related to
STEM. However, this study uses a female-centered STEM figured world in order to develop an interest and sense of belonging in young females at an early age. Integrating STEM into the lives of young females is an untapped opportunity for encouraging a lifelong interest and identity related to STEM that can impact more females pursuing STEM.

**Research Purpose and Questions**

Research is available regarding identity development in early childhood related to science and mathematics. A handful of studies have investigated identity development in formal education (e.g. Chacon & Soto-Johnson, 2003; Peters-Burton, Lynch, Behrend & Means, 2014; Sadler, Sonnert, Hazari & Tai, 2012) and a few others in informal education (e.g. Hughes, Nzekwe & Molyneaux, 2013; Tan, Calabrese Barton, Kang & O’Neill, 2013). Studies in post-secondary education indicate having role models and peers with similar backgrounds, a sense of belonging, agency, and experiencing success are all powerful forces for females developing STEM identities and persisting in STEM pursuits (e.g. Espinosa, 2011; Holmegaard, Madsen & Ulriksen, 2014; Wilson, Holmes, Sylvain, et al., 2012). Studies on the process of STEM identity development, specifically, are sparse.

Research on STEM identity development studies secondary students (e.g. Hughes, Nzekwe & Molyneaux, 2013) or post-secondary students (e.g. Perez, Cromley & Kaplan, 2014). No such studies, to my knowledge, have investigated the STEM identity development in young children, particularly focused on females. I used figured worlds in this study to conceptualize STEM identity development and to study the phenomenon of STEM identity development of females in early childhood. The STEM Princess figured
world marries STEM content with a princess theme to create a female-centered STEM figured world. Participating in the STEM Princess figured world occurred during an intensive informal learning experience called the STEM Princess Ball and continued through at-home STEM learning experiences sent in the mail where girls were engaged in the STEM Princess figured world through videos and STEM activities.

The purpose of this study was to examine the identity development of young White girls related to STEM. In particular, I investigated two cases of White females: those who participated in a female-centered figured world compared to those who did not participate, and the influence that figured world had on their STEM identity development. One way the cases were bound was by demographics: family dynamics, social class, geographic location, sex, and race. Ireland, Freeman, Winston, Proctor, DeLaine, Lowe, and Woodson (2018) describe how girls of color experience STEM through different lens because of their existing identities and the opportunities afforded to them to engage in STEM and interact with members of the STEM community that look like them. I included only White females with the acknowledgement that additional research needs to be done to better understand STEM identity in other racial groups.

In this dissertation, I answered the following question:
How are the STEM identities of White girls ages five to eight years influenced by female-centered STEM experiences compared to similar peers without the same experiences?
Conceptualizing identity required capturing the process of identity construction and relevant practices, including dialog of participants. I answered the overarching research question stated above by answering the following sub-questions:

- What conceptions do participants have of STEM before and after engaging in all-female STEM experiences compared to peers who do not engage in the same or similar experiences?
- How are STEM sense of belonging and self-efficacy of participants influenced by engaging in all-female STEM experiences compared to peers who do not engage in the same or similar experiences?
- How does engaging in all-female STEM experiences influence the interests of participants compared to peers who do not engage in the same or similar experiences?

This study was approved by the Iowa State University Internal Review Board for Ethical Research (see Appendix A). The research was designed and conducted in accordance to standards of ethical and responsible research with children, which prioritized the rights and welfare of participants above other considerations.

**Figured Worlds Theoretical Frame**

One of the greatest strengths of the figured worlds framework is its critical lens: taking marginalized people into account before making decisions. Because White males have historically dominated STEM fields, data could be filtered through a critical lens to help understand how power related to race and sex operates through conceptions and outcomes/interest in STEM (Vossoughi, Hooper & Escudé, 2016). Master and Melzoff
(2016) suggested building bridges to underrepresented groups by confronting cultural stereotypes in order to make STEM more equitable.

Using a critical framework for this study affords analysis and deconstruction of the interactions between the context and individual to reveal the shaping of individuals’ STEM identities. The improvisation, conflict, authoring, and world making participants experience will construct a new understanding of how positioning young females influences their identity development. A critical lens focuses on the interests and funds of knowledge from traditionally underrepresented groups to create a new figured world in which they can play and form new identities. Children’s funds of knowledge is the collections of knowledge from the practices and roles in their families, communities, and culture (Moll, Amanti, Neff & Gonzales, 1992). The alignment of children’s funds of knowledge and figured worlds is essential to identity development.

Figured worlds are “socially produced, culturally constituted activities” where individuals construct identities (Holland, Lachicotte, Skinner & Cain, 1998, p. 40-41). Figured worlds are one of four contexts (positionality, figured worlds, space for authoring, and world making) in which identities are constructed. The figured worlds framework blends the social and personal self in identity formation. In this way, “[the figured worlds] perspective puts together the culturalist and the constructivist positions in a dialogic frame” (p. 15) (see Figure 1). Holland, Lachicotte, Skinner, and Cain (1998) present the figured worlds theory of identity development resting on the shoulders of the cultural perspectives of Bakhtin and the sociocultural perspectives of Vygotsky. Although the perspectives may appear contradictory, the figured worlds framework
adopts beliefs from both perspectives. Holland, Lachicotte, Skinner, and Cain contend identities are constructed in context through social and cultural means (Vygotsky, 1978) while also noting the significance of power and positioning as a part of social and cultural contexts (Bakhtin, 1935).

Figure 1. Connecting figured worlds to other theories.

The sociocultural perspective places social experiences and cultural tools as paramount in shaping children’s beliefs, values, and behavior (Vygotsky, 1978). Expanding on this, Lave and Wenger (1991) conceptualized identity formation occurring through exposure and legitimacy (or lack thereof) to certain communities of practice. The social positioning and power afforded to individuals influence the access and acceptance of persons into environments (Bakhtin, 1935). Further, Holland, Lachicotte, Skinner, and Cain (1998) blur the boundary between person and environment integrating Leontev’s (1978) activity theory: people are actively engaged with and responding to the
environment. This means individuals are shaped by and shape environments. The combination of these perspectives leads to the concept of figured worlds.

“People tell others who they are,” according to Holland, Lachicotte, Skinner, and Cain, “but even more important, they tell themselves and then try to act as though they are who they say they are” (1998, p. 3). How individuals understand themselves and engage with the world beyond self is what Holland, Lachicotte, Skinner, and Cain refer to as identities. In short, identities are the conceptions of self that can form self-control of behavior and agency. Identities vary in degrees of consciousness and objectification. They are ever changing and developing.

Holland, Lachicotte, Skinner, and Cain (1998) state the figured worlds framework “focus[es] on the development of identities and agency specifically to practices and activities situated in historically contingent, socially enacted, culturally constructed ‘worlds’: recognized fields or frames of social life” (p. 7). When individuals intersect with different figured worlds, conceptual understandings of self (identities) and related behaviors (interest and roles) are recognized, sorted, and adopted or dismissed. The heuristic development of identities, then, is dependent upon social, historical, and cultural activities. Holland, Lachicotte, Skinner, and Cain use figured worlds to highlight how behavior is mediated by identities, the sense of self one constructs through social interactions.

Figure 2 depicts how Holland, Lachicotte, Skinner, and Cain (1998) conceived of identities in practice. The arrows indicate that identity development is ongoing and cyclical. Individuals are never completely identity neutral as there are discursive and
positional identities that are placed upon us through social structures. This includes race, sex, class, age, and other social constructs related to power and positionality. This influences which figured worlds we are permitted to enter, engage in, and know. Our existing identities also shape our experiences in these figured worlds. Figured worlds are socially and culturally constructed and perpetuated. The participation is a social process bound by time, culture, and positionality, while we are authoring our identities through acceptance or rejection. Figured worlds influence our existing identities and self-author new ones. The process of self-authoring involves the improvisation of new signs and cultural tools, resolving conflict with other identities we possess, embodying the new identity, and practicing the identity through dialog and participation. The identities we practice, accept, and retain shape our sense of belonging, self-efficacy, interests, and agency. The outcomes of identity development also generate behaviors and conceptions which influence which roles we adopt.

Figure 2. Identities in Practice: The inputs, outputs, and process of identity construction.
The STEM Princess Figured World

The STEM Princess is an existing phenomenon that is a figured world where females and femininity are empowered and positioned as doers of STEM. Children ages three to eight are particularly attracted to princesses because their conceptions of gender are forming and princesses are the extreme of traditionally female appearance and role adoption (Glenn, 1999; Orenstein, 2011). Princesses in popular culture use clothing, hair styles, and other outwardly physical attributes to portray femininity to an extreme. More specifically, elaborate ball gowns with lace and ruffles are commonly paired with high heeled shoes, long hair with curls, and distinct make up that accentuates long eyelashes, big eyes, and pouty lips. Their clothing is typically tight on the torso to reveal an hourglass shape commonly associated with the female body. Each characteristic stereotypically associated with females is over-the-top with popular culture princesses creating an ultra-feminine version of a person embodied by the princess.

The STEM Princess figured world was designed to pair the ultra-femininity of princesses attractive to young females with real-life female STEM professionals to make a novel figured world where young females were empowered. The STEM Princess figured world used the outward ultra-femininty of princesses as a catalyst for interest and engagement of young girls but replaced the behaviors commonly associated with princesses with those of STEM professionals. Ultimately, the goal was to use outward appearance to communicate females could be both doers of STEM and distinctively feminine.
The STEM Princess figured world capitalizes on the attraction to the ultra feminine by engaging young females in STEM activities with a princess-theme and using princesses as an introduction to STEM. However, the figured world of the STEM Princess develops a counter-narrative for traditional princess culture as well as the traditionally masculine conceptions of STEM by focusing the conversations, interests, and actions of female role models in STEM and rigorous STEM experiences. The goal is to appropriate the princess culture with a message of female empowerment. This study centered on the figured world created by activities and experiences connected to the
STEM Princess (see Figure 3). The STEM Princess figured world was designed to position young girls in STEM as they develop their STEM identities.

**Organization of the Study**

The development of identities through engaging figured worlds is a process that occurs overtime. The process described by Holland, Lachicotte, Skinner, and Cain (1998) is both a contemporaneous and long-term process of improvisation, conflict, integration, and dialogue. Capturing the immediate and ongoing process of identity development guided the design and implementation of this study. I reviewed the related literature in chapter two highlighting the gaps and how this study added to the field. In chapter three, I described the methods used to complete the study. Chapter four focused on the findings from the data. Finally, chapter five discussed the findings and presented some suggestions for future research.
CHAPTER 2: REVIEW OF THE LITERATURE

In this chapter, I review the literature on identity construction through figured worlds. I begin by describing the Figured Worlds Framework and how it aligns to STEM identity development. Next, I discuss the connections between gender and STEM in the identities of young girls. I specifically discuss princess culture and the connections to gender conceptions and identities of young girls. Next, I briefly explain the importance of a sense of belonging, self-efficacy, and interest in constructing STEM identity. The discussion on sense of belonging also includes a focused discussion on role models, an influential contributor to developing an inclusive or exclusive sense of belonging for young females. The discussion on self-efficacy contains a subsection on conceptions and stereotypes focusing on how they influence identity development across the lifespan. This chapter concludes with an overview of informal STEM learning experiences and how they influence children’s identities.

Search Description

I searched for and compiled literature for this review using three main venues: citations in syllabi from relevant courses, Google Scholar, and the collections at Iowa State University’s Parks Library. I started by searching the terms STEM, STEM education, and early childhood. This narrowed my search by content. I added the terms identity and identity development to find theoretical and conceptual frameworks that related to my research questions. Once I decided to use the figured worlds framework, I added the terms sociocultural theory, constructivist theory, critical theory, activity theory, and identity in practice. More specifically to figured worlds, I added self-authorship,
mediators, stereotypes, and conceptions to my literature searches. The literature from these searches was used to define the figured worlds framework and in the following review of the literature. Finally, because I focus on STEM identity development of young females in the STEM Princess figured world, I gathered additional literature by searching for females in STEM, girls in STEM, gender conceptions, race conceptions, self-efficacy, sense of belonging, and interest and achievement gaps in relation to my participants. In relation to the STEM Princess figured world, I searched for princess culture, gender conceptions, fantasy world, play, and role models.

My searches resulted in a plethora of literature: books, articles, and academic presentations. After surveying the literature broadly, I focused my review on seven major themes: figured worlds and STEM identity development, identity development in early childhood, princess culture, stereotypes and conceptions, sense of belonging in STEM, STEM self-efficacy, and STEM learning experiences.

**Figured Worlds and STEM Identity Development**

Figured worlds common to children five- to eight-years-old may include home, school, location, and popular culture. For this study, I used the STEM Princess as a novel figured world. The STEM Princess figured world positions young females in informal STEM learning experiences with female-centered participation. The goal is granting young females access to a world from which they are typically restricted, creating a new opportunity for identity development and world making. This is what Bruner (1994) refers to as “turning points,” moments of dramatic changes in identities related to new experiences and life changes.
Numerous studies have used the figured worlds framework to understand identity development in older children and adolescents (e.g. Robinson, 2007; Rubin, 2007; Urrieta, 2007). In this study, I used the figured worlds framework to understand identity development in young children. I did not compare the figured worlds in which children engage (e.g. STEM Princess, school, and home) in this research study. Rather, I investigated how the specific figured world of an all-female informal learning experience influenced the development of identity related to STEM.

The few studies of identity development using the figured worlds framework with young children focus on identity development through play. Notably, Pahl (2005) looked at virtual play as an opportunity to experiment with new identities, while Marsh (2010) analyzed the figured worlds created through virtual play in early childhood. Although Park (2011) did not directly use the figured worlds framework presented by Holland, Lachicotte, Skinner, and Cain (1998), she investigated how young children understand race and ethnicity using Vygotsky and Bakhtin, the same theoretical foundations as figured worlds. Finally, Barron (2013) explored the development of young children’s ethnic identities as they encountered cultural and educational figured worlds. This particular study is significant because the author connected the development of young children’s identities and agency to social practices in figured worlds. In my study, I sought to connect the social practices, power, and positionality in figured worlds with the development of young children’s STEM identities.
**Contexts of Identity Formation**

Holland, Lachicotte, Skinner, and Cain (1998) assert identities form within four main contexts. First, “[f]igured worlds, like activities, are not so much things or objects to be apprehended, as process or traditions of apprehension which gather us up and give us form as our lives intersect them…” (Holland, Lachicotte, Skinner & Cain, 1998, p. 41). Meaning is negotiated within figured worlds as persons make sense of artifacts, practices, and behaviors. Identities are then improvised through the shaping of resources and activities specific to situations. Because the artifacts and practices of the worlds we engage in are constantly changing, individuals and groups are “always engaged in forming identities, in producing objectifications of self-understandings that may guide subsequent behavior” (Holland, Lachicotte, Skinner & Cain, 1998, p. 4).

The second element of identity is positionality. Identities and agency are formed as people “figure” who they are through participating within and across “worlds.” However, not everyone will enter or know all worlds based on circumstance and positionality. Positionality refers to available power and hierarchical placement in the social order (Merriam et al., 2001). Holland, Lachicotte, Skinner, and Cain (1998) argue the most durable social positions are gender, race, ethnicity, or class. The inclusion and exclusion of individuals in figured worlds is directly linked to the power, status, and rank associated with these social positions (Holland, Lachicotte, Skinner & Cain, 1998). Each world has a unique dynamic where individuals are figured differently, experiencing more or less power through positioning.
Figured worlds are significant because the dispositions of the actors are mediated by power and privilege which shapes agency, self-efficacy, interests, sense of belonging, and, ultimately, identity (Urrieta, 2007). In other words, figured worlds are where personal and social identities are produced through positionality, authoring, and world making.

One’s social position—defined by gender, race, class, and any other division that is structurally significant—potentially affects one’s perspective on cultural institutions and the ardor of one’s subscription to the values and interpretations that are promoted in rituals and other socially produced cultural forms. (Holland, Lachicotte, Skinner & Cain, 1998, p. 25)

It is the attention on how positionality and power influence identities that promotes a critical perspective when using the figured worlds framework. Considering how individuals are positioned prior to conceptualizing their perspective permits the researcher to better understand the ways existing and created worlds affect identity construction of marginalized and traditionally underrepresented groups as well as dominant groups. Narratives of identities, then, must provide details about the figured world in addition to individual characteristics in order to deconstruct and reconstruct identity. “Accounts of culture that ignore the importance of social position surreptitiously participate in the silencing of those who lack privilege and power” (Holland, Lachicotte, Skinner & Cain, 1998, p. 25).

Individuals are also discursively positioned through limiting access to roles and contexts as well as media narratives. Positionality is significant to identity development
because it shapes how individuals perceive the world. “Persons look at the world from the position into which they are persistently cast” (p 44). Children learn to objectify themselves through consciously reflecting on their social histories, positions, and experiences (Mead, 1934). “Such objectifications, especially those to which one is strongly emotionally attached, become cores of one’s proactive identities” (Holland, Lachicotte, Skinner & Cain, 1998, p. 4).

The third context of identity development is the space of authoring. Authoring is the process of responding or “answering” to the world. According to Holland, Lachicotte, Skinner, and Cain (1998), authorship is required, but the answers are not automatic. Authorship is neither wholly individual nor completely predetermined by society. Although identity development is a self-activity, it happens in the social and historical practices that are situated and appropriated (or not) by the participants. Identities are worked and reworked through improvisation and practice that connects the intimate with the social (Holland, Lachicotte, Skinner & Cain, 1998). Agency is the result of successful improvisation and movement from novice to expert.

Central to authoring are mediating devices: inter and intra dialog and practices. Mediating devices are signs, objects, and behaviors that are used to manage emotions and behavior (Vygotsky, 1978).

A typical mediating device is constructed by the assigning of meaning to an object or a behavior… [At first], mediating devices may be tangible, used voluntarily and consciously… Repeated experience with the tangible device may
eventually become unnecessary, and its function may be “internalized.” (Wertsch, 1985).

Novel mediating devices, through practice, can be automated into one’s thoughts, thus influencing dispositions and identities (Holland, Lachicotte, Skinner & Cain, 1998).

According to Holland, Lachicotte, Skinner, and Cain (1998), “Identities never arrive in person or in their immediate social milieu already formed... [Identities] do not come into being, take hold in lives, or remain vibrant without considerable social work in and for the person.” (p. vii). In other words, identity development is both a contemporaneous and long-term process of authorship including improvisation, conflict, integration, and dialogue over contextual and historical time. Identity construction is a continuous process occurring within oneself through social interactions.

The fourth and final context of identity formation is world making. “[U]niting the intimate and the social sites of cultural production... set within a larger historical and institutional context... new figured worlds and new identities—both figured and positional—emerge” (Holland, Lachicotte, Skinner & Cain, 1998, p. 235-236). Central to world making is play. According to Vygotsky (1978), play is crucial to developing social competence and understanding symbols of a community. When new social and symbolic competencies are practiced through interplay and meaning making, the imagined context moves toward “publicization” marking the transition into a novel figured world (Holland, Lachicotte, Skinner & Cain, 1998). However, it is important to note a difference between novel and new. Figured worlds build upon each other and are never original. One world
may alter or adopt elements from another creating a new set of practices and roles. However, the world is never completely new.

Play- and fantasy-based figured worlds allow for social experimentation (Vygotsky, 1978). Engaging in alternate figured worlds is a chance to unlearn the socially reproduced practices and orchestrations of the dominant and return to everyday life with an altered sense of self and newly formed identities (Holland, et al., 1998). In this way, play worlds with detachments from reality have the power to alter real worlds. This returns the process of identity development to the first context of figured worlds. The cyclical process of identity development in figured world framework influences whether an individual adopts a particular role or not shaping their overall identity.

**Role Adoption**

Calabrese Barton et al. (2013) use the phrase “identity work” to describe the ongoing effort and practice that is central to authoring and positioning oneself within any domain. This phrase captures the dynamic process of joining new worlds and adopting the associated roles. Just as the figured world shapes the role adoption of the individual, the individual also molds the roles and practices of the world into new hybrid ones (Holland, Lachicotte, Skinner & Cain, 1998). This makes each individual an agent within the system. The process of negotiating roles happens in practice as individuals bring their existing identities and experiences into the world while also constructing new identities through the systemic knowledge and skills as well as social and cultural norms of the world (Holland, Lachicotte, Skinner & Cain, 1998). Adopting new roles, then, is an indicator of identifying oneself as an agent in a system and having others within the
world identify that person as an agent (Holland, Lachicotte, Skinner & Cain, 1998). Dabbling in the adoption of new roles and imitating those roles is an indication of (re)conceptualizing identities. Performance and dialog are characteristic of the new identities transforming into habits.

**Identity Development in Early Childhood**

Identity development is closely related to early childhood because it is also the period when individuals begin to understand social positioning and behaviors related to privilege (Bourdieu, 1984). Bourdieu (1977) argues learned activities, roles, and day-to-day social interactions of childhood become the “organic” activities and sense of self individuals keep into adulthood. For instance, if a young female neither engages in science activities nor sees females in science, the activity of doing science will remain awkward and self-conscious. On the other hand, if a young female has female role models in mathematics and participates in mathematical activities on a regular basis, she is likely to approach mathematics with a privileged social position. “Social positions, in other words, become dispositions through participation in, identification with, and development of expertise with the figured world” (Holland, Lachicotte, Skinner & Cain, 1998, p. 136).

Children’s identity development is heavily dependent on how parents and other important adults situate children into or out of context (Valentine, 2000). The lived experiences of individuals throughout childhood into adulthood shape and reshape their identities (Worth, 2009). How children’s identities are situated influence their relationships with others and filter the ways they perceive themselves, especially in
regard to social structures such as gender (Carver, Yunger & Perry, 2003) and race (Dunham, Stepanova, Dotsch & Todorov, 2015).

The formation of identities undergo a sequential process when children interact with a new world. First, children make meaning of the artifacts and activities, and resolve any conflicts with existing worlds and identities they have already developed. This is the process of improvisation. Finally, through imitation and practice, identities are embodied (Bourdieu, 1977). As the novice moves closer to expert, they are likely to engage in the discourse and activities that shape the world (Holland, Lachicotte, Skinner & Cain, 1998). The same process has the potential to transform and reform the identities and social positions of adults. This study focuses on how this process occurs in STEM identity development specifically in females in early childhood.

**Gender Identity in Early Childhood**

Sex and gender are prominent in identity development. Children become aware of their sex around two to three years old. In comparison, gender development is more fluid process that occurs over time (Martin & Ruble, 2004). Children begin to differentiate between physical permanence of sex and social understanding of gender during early childhood: ages three- to seven-years-old (Bussey & Bandura, 1999). During the same period, the neuroplasticity of the frontal cortex loses flexibility which partially manifests as more rigid definitions, including those related to gender roles (Eliot, 2010). Changes in the frontal cortex of the brain and the resulting development of gender conceptions during this period of growth and development create a critical period for children to place significance on external cues for their internal development (Ruble & Martin, 1998). In
other words, children in early childhood are connecting social and cultural messages from their environment with their biology to assign roles (Fine, 2015). Around the age of nine, the concept of gender has been constructed by stereotypes and social norms in addition to biological sex (Kaiser, Haller, Schmitz & Nitsch, 2009).

Gender development in early childhood is significant because it is performative (Kahle, Parker, Rennie & Riley, 1993). Children as young as two years have exhibited gendered play and awareness of gender norms (Fine, 2015). For example, children expressed an understanding of the “girls do not do math” stereotype prior to entering formal school (Cvencek, Meltzoff & Greenwald, 2011). Similarly, kindergarten and first grade children connect science with masculinity (Hughes, 2001). Persistent exposure to gendered stereotypes lowers the likelihood that girls will participate in STEM activities and constrains their pursuit of STEM careers (Hobbs et al., 2017). In contrast, research on gender development in early childhood indicates exposing children to multiple conceptions of gender and gender roles manifests as a more fluid conception of gender in children and promotes children participating in a broad variety of environments (Coyne, et al., 2014; Pike & Jennings, 2005). Mixing princesses with engineering or dress up with science has the power to shape gendered stereotypes from a very young age (Hobbs et al., 2017).

Other Identities in Early Childhood

Early childhood is a pivotal period for building conceptual understandings of race and gender (Glenn, 1999). Children begin recognizing similarities and differences in race and ethnic backgrounds (Dunham, Stepanova, Dotsch & Todorov, 2015; Porter, 1971).
Ethnic identities are connected to the shared nationality, culture, and language of a group (García, Coll & Magnuson, 2000). Individual’s ethnicity identity can evolve based on geographical changes over time (Goodchilds, 1991). Unlike ethnicity, race is not a personal choice (Takaki, 1993). Race is the physical characteristics including skin color, hair type, and other features used to describe and categorize groups of people (García, Coll & Magnuson, 2000). The power and social implications associated with race are social constructions (Frankenburg, 1993; Smedley & Smedley, 2005). Social stratification based on race is a modern human identity (Smedley, 2008), yet race is one of the earliest social categories children recognize. Preschool children understand race as a physical characteristic, as well as the social implications and identities connected to race (Pauker, Williams & Steele, 2016; Shonkoff & Phillips, 2000).

In “Race” and Early Childhood Education: An International Approach to Identity, Politics, and Pedagogy. Critical Cultural Studies of Childhood, Naughton and Davis (2009) highlight how young children form their own identities with the inclusion of and participation in the politics of race. In chapter five, Davis, Naughton and Smith (2009) emphasize how the politics of race influences the identities of White children, even in early childhood. White children, like children of color, learn the discourses and practices of Whiteness in early childhood (Miller, 2015). Children as young as two understand the social capital that is accumulated through dominant identities including gender and race, which they use to wield power during play and other relations (Skattebol, 2005). This means the intersections of identities, including race and gender, are central to the narratives of identity development.
The identity development of children is influenced by multiple demographic and situational factors which intersect and compound one another (Shields, 2008). This means the STEM identity development of a Black female child will differ from that of a White female child (Jackson III, 2012). Further, other social factors such as class or immigrant status also intersect and compound identity development of diverse females making research challenging (Valentine, 2007). Although I do not examine race, class, or other social factors in this study, the literature demands my attention to intersectionality as a part of identity development. As a result, I chose to control for both race and gender as well as other demographic factors in an attempt to capture the influence of participants’ figured worlds on children’s STEM identity development. The power and influence of the intersectionality between race and gender (Ireland, Freeman, Winston, Proctor, DeLaine, Lowe & Woodson, 2018) coupled with the sensitivity to stereotypes and expectations of females and children of color (Collins, 1998; Shih, Bonam, Sanchez & Peck, 2007) led me to studying a heterogeneous group of participants in an effort to better understand how STEM identity development is influenced by gender-focused figured worlds, in particular.

**Princess Culture**

In her 2011 book *Cinderella Ate My Daughter*, gender development expert Peggy Orenstein refers to four-year-olds as “the gender police” where toys, play, social roles, and behaviors are significantly segmented. Orenstein continues by arguing young girls are inundated with the princess culture which glamorizes femininity and portrays females as passive and at the mercy of males. However, parents often perceive princesses from
popular culture, specifically Disney, as innocent and safe compared to other highly-sexualized female characters (Orenstein, 2011). This may not be completely accurate. Orenstein (2011) linked the princess culture to depression, eating disorders, poor body image, and risky sexual behaviors.

Wohlwend (2009) followed young females who were engrossed in princess culture for three years. The findings of this study indicate princess culture impacted young female’s play and perceptions of gender. Although they did not study princesses, Sherman and Zurbriggen (2014) found playing with Barbies, a similar figure, discouraged girls from considering a broad variety of careers. Similarly, in a reflective study, Coyne, Linder, Rasmussen, Nelson, and Birkbeck (2016) compared the gender stereotypes, body esteem, and social behaviors of teens who watched princess movies compared to those who did not or had limited exposure. The researchers found the portrayals of females and messaging in princess movies had adverse impacts on the teens, including more rigid definitions of gender roles. These results were mediated by parent involvement in play and discussions about the media.

Regardless of the research, Disney princesses remain immensely popular. The franchise of 11 characters sold $2.133 billion in retail merchandise in 2017 alone (The Licensing Letter, 2018). This is likely due to exposure and encouragement from parents as well as peers (Coyne et al., 2016). One year after the publication of Cinderella Ate My Daughter, Orenstein found herself engulfed in the irony. She was the mother of a princess-loving four-year-old. Orenstein (2012) changed the sharpness of her perspective on princesses and pretend. She reframed how young girls “played princess” as a way to
outwardly claim their femininity and embody all that it means to be a girl. “Maybe princesses are in fact a sign of progress, an indication that girls can embrace their predilection for pink without compromising strength or ambition; that, at long last, they can ‘have it all’” (Orenstein, 2012, n.p.). Parents and important adults are charged with teaching girls how to navigate “the contradictions [young females] will inevitably face as a girl, the dissonance that is as endemic as ever to growing up female” (Orenstein, 2012, n.p.). This is the perspective I took when creating the STEM Princess figured world for girls in early childhood.

The early childhood period, ages three to eight years, is a pivotal period for identity development that shapes how young children engage with others and perceive the world (Fine, 2015). Their identities are rapidly forming through self-authoring and social positioning. However, it is significant to note positional identities can be mediated, providing an opportunity to disrupt structures of privilege and move toward liberation from the existing social structures (Holland, et al., 1998). This study worked to mediate the development of identities specific to sex and STEM. I chose to study children ages five to eight because their conceptions of sex and gender are still forming, but they also had time to form identities to be mediated. I used this window of time where children are developing conceptions of gender, yet their preferences, social norms, and stereotypes associated with sex and gender can still be shaped.

**Stereotypes and Conceptions**

Stereotypes are born from conceptions. Strobe and Insko (1989) define stereotypes as oversimplified and prescribed conceptions, opinions, or images. Stereotypes are
cognitive shortcuts that allow the brain make quick judgments using visible characteristics such as gender, race, and age. Stereotypes are not necessarily bad until they are used to categorize or generalized on to a whole group (Fiske, 1998). For instance, “boys are better at mathematics than girls” is a stereotype about gender generalized to a broad, dynamic field.

Stereotypes shape actions and interactions between individuals and the outside world (Bordalo, Coffman, Gennaioli & Shleifer, 2019). Stereotypes are socially transmitted, but can be internalized (Conway, Pizzamiglio & Mount, 1996). Negative stereotypes can result in the retardation of self-efficacy (Conway, Pizzamiglio & Mount, 1996). Returning to the previous example, stereotyping only boys as good at mathematics has the power to negatively shape identities between females and mathematics. Unfortunately, even minimal exposure can increase children’s and adults’ acceptance of stereotypes (Orenstein, 2011). Fortunately, stereotypes are malleable and can be moderated or mitigated with counter narratives. Females with persistent exposure to figured worlds with females in STEM do not hold the same masculine stereotypes related to STEM (Tan et al., 2013).

Young children gather information about gender identity and stereotypes from an array of social contexts: school, family, and media (Saltmarsh, 2009). Stereotypes form from an early age shaping the way individuals and society frame other individuals and groups (Ramsey, 2004). Children, even those as young as two, construct conceptions based on their observations and experiences (Piaget and Inhelder, 1971). Children in early childhood exhibited measurable, consistent gender stereotypes (Ruble, Martin &

Martin and Ruble (2004) describe children in early childhood education as “gender detectives who search for cues about gender – who should or should not engage in a particular activity, who can play with whom, and why girls and boys are different” (p. 67). Gender stereotyping, according to Trautner, Gervai, and Németh (2003), occurs across early childhood in three phases: learning about gender (3-5 years), rigid gender definitions and stereotypes based on learning phase (5-7 years), and evolving flexibility in gender stereotypes by age eight. Imaginative play and figured worlds allow children to experiment with gender roles and norms prior to forming rigid gender conceptions (Chick, Heilman-Houser, & Hunter, 2002). Boys and girls begin preferencing characters, activities, and toys based on gender during the same period (Freeman, 2007).

Gender conceptions and stereotypes formed as children set in motion life-long conceptions of masculinity and femininity as well as limit role adoption and interests (Martin & Ruble, 2009). Care, Denas, and Brown (2007) found 4- and 5-year-old children’s categorizations of career fields as male, female, or neutral coincided with national statistics of that occupation. By elementary school, children are developing conceptions and stereotypes relating gender to intangible characteristics. Bian, Leslie and Cimpian (2016) found kindergarten boys and girls believed boys and girls were equally intelligent. After assessing stereotypes again in second grade, girls remained constant in
their equitable beliefs stating girls are smart, but boys are smart too. Boys’ conceptions, on the other hand, shifted to believing boys were smarter than girls. Applying strategies designed to change children’s perceptions and conceptions of STEM in elementary grades may be too late (Fine, 2015). The gender stereotypes formed in early childhood impact educational and career pursuits, relationships, role adoption, and overall happiness (Hendrix & Wei, 2009).

These findings are significant to this study because the findings indicate children are developing conceptions related to academics and gender in kindergarten, first, and second grades. This was the period of focus of this study. Other research confirms Bian, Leslie, and Cimpian’s findings while also noting children’s gender stereotypes are flexible and can evolve over time (e.g. Rowley, Kurtz-Cotes, Mistry & Feagans, 2007; Trautner, Ruble, Cyphers, Behrendt & Hartmann, 2005). This indicates purposeful positioning of children into STEM worlds may have the power to influence the development of their STEM identities, even at a young age. Furthermore, females are particularly sensitive to stereotypes and swayed by their messages (Collins, 1998; Shih, Bonam, Sanchez & Peck, 2007). Creating a female-centered figured world where young girls can participate as doers and knowers of STEM has the potential to influence their identity development and shape their conceptions related to sex and STEM.

**Stereotypes and Conceptions Related to STEM**

Over 30 years of findings consistently highlight the stereotypical conceptions held about the STEM community as early as elementary school: White, male wearing a white coat and glasses who appears socially inept (i.e., isolated, “geeky”, mad) and is working
indoors surrounded by symbols and tools salient to STEM fields (Chambers, 1983; Knight & Cunningham, 2004; Picker & Berry, 2000). Because stereotypes are rebuffed or confirmed in social experiences, the underrepresentation of females and people of color in STEM fields shapes the conceptions children have of who belongs in STEM. Media related to STEM with a child audience confirms the White male in STEM with characters such as Jimmy Neutron, Sid the Science Kid, and others. When coupled with the proliferation of images of Einstein, Newton, and others in schools and other mediums, a common conception of who belongs in the STEM community is a stereotypical image of old, White males.

This indicates children perceive those who belong in the STEM community as White, male, geeky, and naturally smart. Females and people of color are not a part of the stereotypic STEM community, which is a powerful force in shaping a sense of not belonging (Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013). This presents an opportunity to influence the STEM identities of children who do not fit the stereotypic STEM identity by positioning them into worlds where they are empowered by role models and the context of the environment.

The gender gap in STEM starts at an early age and continues into adulthood. On surveys and via course selection, girls begin expressing disinterest in STEM fields at the middle level. However, male dominance in STEM-based play emerges in elementary-age children and younger (Orenstein, 2011). It is common in preschool classrooms for block stations to be inhabited by more male students and dress up corners by females (Trawick-Smith, Wolff, Koschel & Vallarelli, 2015). Children begin associating toys and other
objects related to STEM (e.g. blocks, science fiction, paleontology) with males as early as the toddler years (Martin, Eisenbud & Rose, 1995).

Archer et al. (2010, 2013) reported the personal identities of children did not match those necessary for working in science classrooms. In one study, Archer et al. (2010), studied nearly 10,000 elementary students and their science identities. The authors reported elementary children believed they could do science, but they did not perceive themselves as scientists or believe they would become scientists. In a related publication using the same study, young girls expressed science aspirations were out of the question and did not fit within their existing identities (Archer et al., 2013). Even when girls expressed enjoyment in doing science, the authors note girls did not want to pursue a science career as they perceived scientists as geeky, manly, and not nurturing. In other words, the stereotypes associated with science, and STEM more broadly, were perpetuated in the classroom skewing the female students’ identities away from STEM.

The early elementary years are a prime time to influence children’s STEM identities (Ambady, Shih, Kim & Pittinsky, 2001; Côté & Levine, 2014). More specifically, exposing female children to female role models in an informal STEM learning environment is a powerful tool for building positive identities (Rivardo, Rhodes, & Klein, 2008) and increasing interest in STEM (Chacon & Soto-Johnson, 2003). How young females interact with STEM and the STEM community affects their conceptions of STEM, self-efficacy, sense of belonging, and interests. Archer et al. (2017) found girls, even from a young age, struggle to reconcile gender identities with STEM stereotypes, which impedes their STEM identity development.
Research shows the majority of school-aged children and adults perceive STEM as useful, but complex and intimidating (Knezek, Christensen & Tyler-Wood, 2011; PCAST, 2010) causing them to lose interest in pursuing STEM (Maltese & Tai, 2011; Wyss, Heulskamp & Siebert, 2012). This, coupled with another critical period of identity development, is the reason STEM initiatives focus on secondary students: rekindling their interest in STEM. DeJarnette (2012) suggests a more proactive approach: capturing interest in STEM at an earlier age through diverse exposure and creating a sense of belonging for all children (DeJarnette, 2012). It is imperative to provide girls with more opportunities to engage with women in STEM, even at a very young age, if we hope more girls gain an interest and passion for STEM. Developing a positive STEM identity has long-term implications on how to engage, motivate, and inspire females to enter into STEM fields (Archer et al., 2013; Sadler, Sonnert, Hazari & Tai, 2012; Wang, 2013).

**Role Models**

Early and persistent exposure to role models (individuals with similar gender, race, and histories as them) in STEM fields is elemental in shaping a sense of belonging, self-efficacy, and interest (Ong, Wright, Espinosa & Orfield, 2011; Weber 2011). Cheryan, Siy, Vichayapai, Drury, and Kim (2011) found role models who challenge stereotypes associated with STEM are particularly important to shaping the self-efficacy of female participants. Regardless of age or setting, role models in STEM are particularly important to the engagement and persistence of females in STEM (Drury, Siy & Cheryan, 2011; Trenor, Yu, Waight, Zerda & Sha, 2008).
A dearth of highly-qualified, well-prepared teachers coupled with limited resources and few role models are limiting factors for historically underrepresented groups to engage in formal STEM (National Research Council [NRC], 2011). Further, the underrepresentation of females in formal STEM education have manufactured positional identities that present STEM-related domains as male-dominated (Hull & Greeno, 2006). Bachman, Hebl, Martinez and Rittmayer (2009) found formal STEM educational settings often foster the interests of male students while deterring and departing from the interests of female students.

Early childhood STEM experiences that incorporate female community members are particularly salient for the development of STEM interest and identity in young females (Stout, Dasgupta, Hunsinger & McManus, 2011). Therefore, it is critical to provide role models in STEM for students to develop identities as STEM learners and begin to view themselves as scientists, mathematicians, and/or engineers even if they do not enter into these fields. Exposing children to role models that have shared characteristics to them has the potential to create a new sense of belonging, spark interest, and push children toward developing new identities related to STEM (BarNir, Watson & Hutchins, 2011; Drury, Siy, Cheryan, 2011; Marx & Roman, 2002). Forming dynamic conceptions of the STEM field is critical to expanding those who identify as a member or potential member of the STEM community.

**Sense of Belonging in STEM**

Cheryan, Plaut, Davies, and Steele (2009) investigated females pursuing computer science. They defined sense of belonging as the match or mismatch between an
individual and the environment or culture. In this study, I draw on their definition of belonging: the sense that I am like the stereotypic images, content, people, and activities within that environment. According to this definition, the message about who does and does not belong is portrayed by media, physical objects, and other environmental cues because they portray a certain culture and those associated with that culture (Murphy, Steele & Gross, 2007). It is important to denote the difference between Cheryan, Plaut, Davies, and Steele (2009) use of stereotypical as an adjective and stereotypes. Like a stereotype, stereotypical images, content, and activities are over simplified conceptions widely associated with a particular field. Unlike stereotypes, stereotypical imagery is not founded on social categories such as gender, race, and age as it is describing inanimate objects. For instance, safety goggles and lab coats are stereotypical images related to science. Stereotypes, in contrast, are specific to the social and political identities of persons. When existing personal identities, such as being female, match with the social and cultural cues of the environment, this fosters a sense of belonging (Master, Cheryan & Meltsoff, 2016). According to seminal work by Baumeister and Leary (1995), a sense of belonging drives interest, and happiness. This makes interest, and sense of belonging critical components of self-efficacy, and, ultimately, identity development.

The pipeline into STEM careers begins with fostering a sense of belonging in STEM disciplines (Elam, Donham, & Solomon, 2012; NAPE, 2009). A sense of belonging forms when the conceptions and stereotypes of the participants, as well as the social and cultural norms, are similar to self. One of the largest gaps in interest and achievement in STEM fields is between males and females indicating females do not feel
like they belong in STEM (NAPE, 2009; National Science Foundation [NSF], 2013; PCAST, 2010). Exacerbating the problem is the underrepresentation of these individuals currently working in STEM careers. The lack of gender diversity in STEM fields shapes how welcome females feel and reinforces the stereotype of STEM participants as male (Riegle-Crumb, King, Grodsky, & Muller, 2012).

Carlone, Scott, and Lowder (2014) observed the stem identity work of young girls over time. The authors reported girls pulled away from science and STEM classes while still in elementary school. However, their course selections and preferences in middle and high school were a reflection of the erosion of their sense of belonging in science and their overarching STEM identities. From elementary through middle school, girls were decidedly less scientific and more averse to pursuing science-based courses and careers. The participants shared their personal identities, particularly that of female, did not match the culture and climate of science as they saw it. In this study and others (e.g. Archer et al., 2010; Archer et al., 2013; DeWitt & Archer, 2015), gender significantly impeded girls from feeling like they belong in STEM.

Widespread research on the culture of STEM indicates a fundamental sense of masculinity (Archer et al., 2017). Calabrese Barton and Tan (2009) found the funds of knowledge and interests of female students were often not honored or perceived as valuable in STEM-related activities when compared to those of male students. In a later study, Tan, Calabrese Barton, Kang, and O’Neal (2013) reported girls who manage to persist in their pursuit of STEM undergo a series of negotiations to author their STEM
identities. Participants reported outside support and affirmation of their STEM identities were significant in making them feel validated and on the right trajectory.

Negotiating meaning requires a period of improvisation where children can explore and play with objects, roles, and norms in new worlds. The purposeful play pedagogical approach to early childhood gives children an opportunity to make meaning through objects and relationships while also exploring social roles and norms related to STEM (Moomaw & Davis, 2010). Experiences with STEM in early childhood often prevail into adolescence and adulthood (Bybee & Fuchs, 2006). Limited exposure, negative experiences, and a lack of success create disinterest and diminish students’ sense of belonging by middle school, fading their interest in mathematics and science (Holdren, Lender, & Varmus, 2010).

Though female representation has increased over the last 10 years from under 25% of the STEM workforce to nearly 50%, their representation varies widely across fields (Funk & Parker, 2018). For example, women make up 75% of all health-related jobs and only 14% of jobs related to engineering. Furthermore, women are exponentially more likely to hold subordinate positions with lower pay. This significantly reduces the number of role models in STEM for females and shapes an exclusive perception of the STEM community. Ultimately, a lack of female representation in STEM negatively impacts girls’ sense of belonging (Chacon & Soto-Johnson, 2003; Archer et al., 2010; Archer et al., 2013). The demographics of students pursuing STEM-related post-secondary education and advanced high school STEM courses are similar (White House, 2009).
**STEM Self-Efficacy**

Self-efficacy is the self-perceived competence of an individual (Bandura, 1977). It is significant to understand self-efficacy is not specific to a particular condition or trivial task. Instead, self-efficacy is the beliefs held about an individual’s ability to make connections between knowledge and choreograph skills across situations and context (Bandura, 1977). If an individual has high self-efficacy, they believe they are capable of performing a behavior that will produce a desired outcome (Maddux, 2016). These beliefs about capabilities develop across time, contexts, and experiences (Maddux, 2016). Responsive and inclusive environments facilitate the development of self-efficacy while exclusive environments and negative or non-responsive environments will slow or diminish the development of self-efficacy (Bandura & Wessels, 1997). In other words, the development of self-efficacy happens through social and cultural interactions.

Self-efficacy is an important part of studying identity because it encourages children and adults to explore and try new things, which creates an opportunity to build new identities, especially those related to careers (Nauta, 2004). The rationale for the close relationship between self-efficacy and career interest is provided by Social Cognitive Career Theory (SCCT). SCCT postulates increases in self-efficacy precede growth in career interests (Lent, Brown & Hackett, 1994). Several studies have researched the significance of identities in practice and the relationship between self-efficacy and career choice. Barnatt et al. (2017) found teacher career decisions and identity building were closely linked to the development of self-efficacy, agency, and the figured worlds in which they engage. Similarly, career interests have been used as a
measure of self-efficacy broadly (e.g. Nauta, 2007), as well as in a variety of fields including mathematics and science (e.g. Larson, Pesch, Surapaneni, Bonitz, Wu & Werbel, 2015; O'brien, Martinez-Pons & Kopala, 1999) and STEM (e.g. Fouad & Santana, 2017; Tellhed, Bäckström & Björklund, 2017). The sequence of self-efficacy to career interest may also manifest as self-efficacy to role adoption in childhood (Bandura, Barbaranelli, Caprara & Pastorelli, 2001).

Self-efficacy shapes children’s career aspirations to a greater degree than academic achievement and socio-economic status (Bandura, Barbaranelli, Caprara & Pastorelli, 2001). Measures of STEM self-efficacy are predicted by gender and predictive of many choices that lead to career attainment (Brown & Lent, 2013). Middle and high school course selections as well as undergraduate majors are all strongly related to self-efficacy (Parker et al., 2014). Graham, Frederick, Byars-Winston, Hunter, and Handelsman (2016) argue self-efficacy is a requirement for persistence and agency in STEM. Females’ academic and career decisions are markedly influenced by self-efficacy (Creamer & Laughlin, 2005). Unfortunately, females traditionally hold lower efficacious beliefs in STEM when compared to their male counterparts (Louis & Mistele, 2012). Providing welcoming STEM experiences for girls to build their STEM self-efficacy is one potential way to build up their career interests and future trajectories associated with STEM. In reverse, girls who hold career and education aspirations related to STEM would also convey a greater self-efficacy in STEM.

Calabrese Barton et al. (2013) found the identity work of female students was heavily influenced by the interactions with and feedback from others. When girls
engaged in novel STEM activities or worlds, they were more likely to author those experiences into future selves when their participation and work was recognized and supported by peers and experts alike. The authors note the expansion of opportunities to participate in STEM activities was critical to shifts and a continuation on a trajectory toward constructing a STEM identity. Crafting meaningful identities related to STEM required girls experiencing ongoing, cumulative success in STEM.

In order to “[reimagine] the pipeline,” Allen-Ramdial and Campbell (2014) argued there needs to be a concerted effort toward building positive self-efficacy in females and other underrepresented groups. The authors recommended (1) shaping culture and climate to match those familiar to females, (2) building dynamic partnerships, (3) building and sustaining female participation in STEM, and (4) encouraging the involvement of role models. The final suggestion was exceptionally important as numerous studies report the self-efficacy of children is influenced by the self-efficacy of their role models and teachers (Caprara et al, 2006).

Riedinger and Taylor (2016) studied the identity development of girls who engaged in a week-long summer camp. Girls spent the camp working on authentic tasks using tools of the discipline along-side scientists. More specifically, the scientists were primarily females. The authors reported the welcoming and safe environment permitted girls to explore science and fostered the development of positive STEM identities. By the end of the camp, participants acknowledged many of their stereotypes were challenged, forcing them to rethink their own abilities in STEM (Riedinger & Taylor, 2016).
Participating in formal and informal STEM experiences as in early childhood significantly increased the children’s self-efficacy and interest in STEM (Hughes, Nzekwe, & Molyneaux, 2013). For example, Mohr-Schroeder et al. (2014) found children who engaged in a week-long STEM summer camp reported a greater sense of belonging, higher self-efficacy, and an increased interest in STEM. Long term, the likelihood of pursuing a STEM career in the future is related to the formal and informal STEM learning experiences during childhood (Dorsen, Carlson, & Goodyear, 2006; PCAST, 2010).

Calabrese Barton and Tan (2010) found children who participate in STEM activities focused on real-world problem solving have an increased sense of capability. Participants presented themselves as experts engaging in dialog and adopting the roles indicative of developing identities salient to science. Similarly, Kangas, Seitamaa-Hakkarainen, and Hakkarainen (2013) found the self-efficacy related to design and building multiplied when young girls were connected with expert designers. Ramm (2007) also reported significant growth in the confidence and development of an expert perspective when students engaged with experts during an eight-week program. In all three studies, the interaction with expert role models was cited as a source of increased self-efficacy of the young female participants.

**STEM Learning Experiences**

A formal STEM learning experience, for the purpose of this study, is one that occurs in the structured context of a PK-20 classroom with a highly-qualified teacher and curriculum. This includes, but is not limited to, subject-area classes that are integrating
other areas of STEM as well as STEM-specific classes (Felder & Brent, 2016). Although gaining in interest and popularity, there are significant gaps in the literature about how to best integrate STEM into formal school settings, and how integrated STEM impacts learning outcomes (Honey, Pearson, & Schweingruber, 2014; Mohr-Schroeder, Bush, & Jackson, 2018). Early childhood education is just beginning to integrate STEM and the development of STEM curriculum is slowly following (Katz, 2010). However, not all children have access to good early childhood programming and even fewer have access to STEM in their formal learning environments in early childhood (Chesloff, 2013). The lack of access and equity in STEM education, especially in early childhood, is concerning.

Informal learning experiences provide an alternative pathway for students to engage with STEM and STEM professionals, beyond classrooms teachers. These are public spaces, camps and clubs, museums, libraries, and other non-traditional settings where learning takes place (Schugurensky, 2000). The settings are crucial because informal STEM learning is shown to increase student engagement and interest in STEM (Nugent, Barker, Grandgenett, & Welch, 2016; Yilmaz, Ren, Custer, & Coleman, 2010). STEM experiences with strong considerations in regards to climate and supports are particularly successful with shaping the perception of the STEM field as an inclusive place for females (Chacon & Soto-Johnson, 2003; Frost & Wiest, 2007; Palmer, Maramba, & Dancy, 2011). Extracurricular interventions, or informal experiences, have the additional benefit of presenting underrepresented groups with the opportunity to interact with STEM students in real-world contexts that positively change their
perspective on the STEM disciplines and attending college (Selover, Dorn, Dorn, & Brazel, 2003).

The personal interests and identity components built during experiences are key components in inspiring students to pursue careers and paths in STEM learning (Bell, Lewenstein, Shouse, & Feder, 2009). Weber (2012) found elementary girls who engaged in an informal STEM learning environment experienced increases in interest, self-efficacy, and participation in STEM. One example of an informal STEM learning environment that is especially attractive to elementary students is camps/events (Davis & Hardin, 2013).

Several nationally-funded projects have found informal learning environments increase access to the STEM community and associated content (NRC, 2010), improve communication between experts and the general public (NRC, 2016), and promote a deeper understanding of STEM concepts (National Science Foundation [NSF] & Institute of Education Sciences [IES], 2013). Perhaps most significantly, informal learning experiences can help level the playing field for participants from traditionally underrepresented groups by facilitating connections with formal learning environments and classroom experiences (NRC, 2015).

Informal STEM learning environments present underrepresented groups with the opportunity to interact with STEM subjects in real and contextual ways that positively change their conception of STEM disciplines and attending college (Selover, Dorn, Dorn, & Brazel, 2003). Informal STEM experiences have the potential to broaden participation of traditionally underrepresented groups by engaging diverse audiences using targeted,
specific learning opportunities (Dancu & Garcia-Luis, 2016; NRC, 2009). Informal learning experiences can adapt to the cultures, resources, sex, language, and other considerations specific to participants (Dawson, et al., 2015).

Informal STEM learning is particularly effective with traditionally underrepresented groups such as females (Mohr-Schroeder, Jackson, Miller, Walcott, Little, Speler & Schroeder, 2014) because it provides a counter-narrative to the White, male stereotype and corrects misconceptions about STEM (Bond, 2016; Muzzatti & Agnoli, 2007;). Programs with a strong emphasis on role models similar to participants are shown to increase the retention and success of females in STEM (Chacon & Soto-Johnson, 2003; Frost & Wiest, 2007; Palmer, Maramba, & Dancy, 2011). Furthermore, a diverse body of role models can help to correct misconceptions about the STEM community (Bell et al., 2016; Muzzatti & Agnoli, 2007). Shaping the identity of the STEM community as inclusive has the potential to impact the sense of belonging, interest, and self-efficacy for females. Long term, students who engaged in informal STEM learning are more likely to have increased interest in formal STEM learning and related careers (Roberts, et al., 2018).

This study capitalizes on the flexibility and influence of informal STEM learning environments on traditionally underrepresented groups, namely females. The informal setting allows children to learn with and from a diverse set of role models from STEM fields as well as peers with similar interests. Further, using an informal STEM learning environment lowers barriers to entry for females and allows them to play with gender roles and enter spaces that are typically occupied by young females. The combination of
positioning, a princess theme, role model and content exposure, and play within an informal environment is vital to how this study approaches influencing the STEM identities of young females.

**Conclusion**

The masculine conceptions and stereotypes related to STEM manifest in early childhood and persist into adulthood. They form barriers for girls to participate in STEM by not fostering a sense of belonging, and by impeding the development of self-efficacy. These are the central tenants to the formation of STEM identities. To alter girls’ conceptions and stereotypes of STEM, they must have a chance to participate in a counter-narrative positively connecting STEM and femininity. In this study, I argue constructing a female-centered figured world merging princesses and other popular interests of young girls with STEM role models is one promising approach to building positive STEM identities.
CHAPTER 3: METHODOLOGY

This qualitative research study used a collective case study approach (Stake, 1995) to explore and understand the complex process of STEM identity development of White females ages five- to eight-years-old within the bounds of a figured world. Children’s engagement, or lack thereof, in the STEM Princess figured world permitted the investigation of the identities children construct from their experiences (Merriam, 2009). “Culture and subject positions are important components of the working of identity, but cultural production and heuristic development are the keys to its analysis” (Holland, Lachicotte, Skinner & Cain, 1998, p. 46). Therefore, the data in this study focused on the process of identity development rather than a finite identity as an end product.

Data were analyzed using a priori coding from the process of identity development and figured worlds discussed by Holland, Lachicotte, Skinner, and Cain (1998). Using a collective case study approach helped me conceptualize the process of STEM identity development in young children and how this is influenced by engaging in a female-centered figured world. I did this through observation, participant input, reconstruction, and analysis of both cases (Tellis, 1997). This chapter details the research design including the collective case study method, data collection, and analysis plan I used to answer the research questions.
Research Questions

How are the STEM identities of White girls ages five- to eight-years old influenced by female-centered STEM experiences compared to similar peers without the same experiences?

In order to answer the overarching research question, I sought to answer the following subquestions.

• What conceptions do participants have of STEM before and after engaging in all-female STEM experiences compared to peers who do not engage in the same or similar experiences?

• How are STEM sense of belonging and self-efficacy of participants influenced by engaging in all-female STEM experiences compared to peers who do not engage in the same or similar experiences?

• How does engaging in all-female STEM experiences influence the interests of participants compared to peers who do not engage in the same or similar experiences?

Research Design

I used case studies to conceptualize how the STEM identities of the participants were influenced by female-centered STEM experiences when compared to similar peers without the same experiences. Yin (2017) states a case study approach should be considered when (1) using “how” and “why” questions, (2) the behavior of participants cannot be changed or manipulated, (3) the context is important to the phenomenon under study, and (4) the context and phenomenon are not separated. Cases are defined by the
bounded context in which the phenomenon under study is occurring (Merriam, 1998). Clearly binding cases by definition and context is essential because the case is “in effect, your unit of analysis” (Miles & Huberman, 1994, p. 25). This means the boundaries of the case studies both drive the depth and breadth of the study as well as sample selection.

A case study is “a specific, a complex, function thing… an integrated system”, and each case “has a boundary and working parts” (Stake, 1995, p. 2). According to Stake (1995), the case study approach begins with refined research questions that “help structured the observation, interviews, and document review” (p. 20); however, the flexibility of case study designs “[forces] attention to complexity and contextuality” (p. 16) because predicting the path of qualitative studies cannot be done in advance. The complexity of case studies means there are more variables than possible data points. Findings capitalize on the a priori theory and data triangulation to conceptualize the complexity of each of the cases (Stake, 1995).

The overarching goal of case study inquiry is creating rich, thick descriptions of the cases that lead to themes the research can use to compare and contrast the unique features of each case within the bounds set (Stake, 1995). In order to do so, data must come from multiple sources that can be used to construct the case narratives (Stake, 1995). Multiple data sources enhance the credibility of the data itself and the findings (Stake, 1995).

Stake (1995) characterizes three types of case study: intrinsic, instrumental, and collective. According to the author, a researcher uses an intrinsic case study to undertake learning about a unique phenomenon that is distinguishable from all others. An
instrumental case study is used to gain a broader understanding or application of a phenomenon using a particular case. Finally, Stake’s collective case study involves studying multiple cases sequentially or simultaneously to gain an even broader comprehension of a particular phenomenon. In this study, I used a collective case study approach to conceptualize the identity development in young females who participated in a female-centered STEM figured world compared to those who do not.

Figure 4 depicts the bounds of the cases in this study. The collective case approach was a good fit for this study because it provided a pathway for understanding identity development within and across the cases while also studying more than one individual. Studying a small group as a collective case afforded me an opportunity to better understand process of STEM identity development instead of the identity of a single child. While the phenomenon of identity development is well studied, less is known about the process of identity development in young children. I did not argue the process of identity development in these cases was unique or particular to the participants. I instead sought to gain a broader understanding of how the creation of figured worlds influenced STEM identity development in females.
According to Stake (1995), case study methodologies are a good fit for studying participants within their natural context to gain understanding of a phenomenon. This aligns with Holland, Lachicotte, Skinner, and Cain’ (1998) figured worlds framework where identities are formed by individuals within worlds where, in turn, the individuals shape the world. I did not seek to conceptualize the STEM identity development of individual participants across their figured worlds. Rather, the current study used a descriptive, collective case study design to investigate the broader phenomenon of STEM identity development that occurred within two different contexts: the STEM Princess figured world and Business as Usual. The cases were constructed through a holistic, in-depth approach. I worked in close proximity with participating children to conceptualize their STEM identity development using rich, thick narratives (Crabtree & Miller, 1999) which enabled me to explore the differences within and between the two cases in the
collective design. The resulting cases are valuable because they contribute to understanding STEM identity development in young children as well as how figured worlds can influence the identities of young females.

**Researcher Positionality**

I am the mother of three little girls who love dressing up, hunting for bugs, making believe, exploring outside, and toying with technology amongst other STEM and princess-y things. I created the STEM Princess after my then-four-year-old daughter refused to go to a science camp despite her love of science and exploration at home, proclaiming, "I want to be a princess. Science is for boys!" Even with a female-empowered home environment, my daughter thought she could not be a scientist AND a princess, too. My personal experience is a similar story.

I loved all things STEM as a child, spending my time building, creating, inventing, and exploring. I collected frogs and bugs to study them. I disassembled clocks to discover how they worked and assembled other things to fix them without directions. Further, I did well in my science and mathematics classes in school. My interests and successes were not enough to keep me on the path to a STEM career. Instead, I chose education and social science. I come from a family of teachers and lovers of history, which made a social studies education degree look like a good fit for me. While I loved teaching social studies, I continued to spend my personal time building, creating, inventing, and exploring. In other words, I was spending my free time doing what I was interested in as my professional time was spent doing what I thought I was good at. I wanted my daughter, and other girls, to feel like they could be interested in and good at
STEM because they belong in STEM. Creating a positive and inclusive STEM environment for my daughters and other children was the catalyst for the creation of The STEM Princess.

I closely interacted with parents, children, and volunteers during all STEM princess activities and the collection of the data for this study. This included promoting STEM Princess events to parents and answering any questions they may have before, during, and after their children participated. I intimately interacted with the children and families participating in this study, spending multiple hours interviewing and interacting with them over the course of five months. I was an active participant in this research study as a facilitator and collector of data.

I acknowledge my deep connections to the STEM Princess created a level of subjectivity. Although I created and continued to facilitate the happenings of the STEM Princess, this is a self-funding organization without any personal financial benefit, reducing some of the subjectivity and potential motivation for skewing findings. I further addressed my subjectivity by involving a graduate student and two professors to consistently evaluate my data collection, analysis, and findings. Additionally, the members of my dissertation committee were acutely aware of the potential for subjectivity in this study and acted as a safeguard.

I identify as a White female from a middle-class background. Because these identities parallel the participating children, I conducted member checking with each child to make sure the findings accurately portrayed the perspectives of participants. After constructing the two cases, I shared the overarching themes with the participants in
child-friendly language to get feedback and validation from them. Our similar identities
gave me insight into the issues and influences these children experienced related to
STEM and identity development.

**Context**

The STEM Princess Ball is an annual event where the figured world described in
chapter 1 and detailed below comes to being. The three-hour informal learning
experience for this study was held in the Upper Midwest region of the United States.
Children in attendance ranged in ages from three to nine years. The schedule of events
began with a brief whole-group activity and child-friendly explanation of the STEM
content which is the foundation for the remainder of the event. For instance, the theme of
the event for this study was “Physics and Flight.” The beginning activity included
demonstrations of waves, disturbances, force, and aerodynamics.

Participants broke into small groups after the initial group demonstrations. These
small groups spent the next two hours rotating through stations where they engaged in
STEM-related problem solving, exploration, and experimentation connected to the event
theme. Small groups were further divided by age: before kindergarten and kindergarten
and after, the focal group of this study. Volunteers and parents also refer to these groups
as “little kid” and “big kid” groups. Groups spend 20 minutes at each station with five-
minute rotation period. The stations were purposely designed to engage children in
STEM practices as well as conversations with facilitators and role models.

Station activities presented at the “Physics and Flight” STEM Princess Ball for
little kids included constructing and testing vortex cannons, learning how sound travels
through using string, and using thermochromic pigment to make heat-sensitive slime. Big kid stations for the STEM Princess Ball included building balloon-powered LEGO cars, testing and redesigning their LEGO cars, and comparing the functioning and flight of paper gliders versus hoop gliders. One of the stations, designing and building air powered rockets, was completed by both groups of attendees. Facilitators were trained before the event on the activities and content of the stations, described in the following paragraphs.

At the first little kid station, children made thermochromic slime. They mixed salt (borate ions), baking soda, and saline solution with the polyvinyl-acetate (PVA) in glue. Children learned the PVA (the glue) is a polymer made up of long, repeating strands. When they added the saline solution to the glue, the polymer strands connect and tangle together to make a thicker, rubber-like substance we call slime. Because slime is neither a liquid nor a solid, STEM professionals call it a Non-Newtonian fluid. This means it is a little bit of both! This particular slime also had a special ingredient: pigment that changes colors based on temperature. The facilitators used friction with their hands to teach about heat as energy. The hotter something is, the more energy it has. In the slime, the heat waves from their hands changed the color of the thermochromic pigment. The idea of transferring energy traveled to the next station.

The second station for little kids had activities demonstrating how sound waves travel through matter (air and fabric in these cases). Children experienced how the sound waves we hear can be altered by how they enter our ears. By tapping a metal fork tied to a piece of yarn with a ruler, the children heard a ping. Next, they wrapped the string tied to the fork around their fingers and placed their fingers into their ears. When the ruler
tapped the silverware again, it caused the same type of disturbance as before, but the sound was much louder and longer lasting because the waves created traveled directly into the ear through the vibrating string. Making the intangible tangible was also the focus of the third station.

Children created and tested vortex cannons at the third station. Since air is invisible, it is hard for young children to conceptualize movement of air. This station made an air or vortex cannon to get students thinking about the power air movement has. This activity demonstrated that air occupies space and Bernoulli’s principle (faster air = lower pressure). Since the air exiting the air cannon was moving faster than the air outside, it formed a vortex: a spinning flow of fluid or gas that holds the air together in a ring shape. Children aimed their cannons at lit candles because the same fast-moving air that caused the vortex to form was also a force that could do work such as blowing out a candle.

The last activity, the one shared activity, was designing and building air powered rockets from plastic test tubes. This activity had similar content with the explanations modified for younger and older children. All children created a rocket using a plastic test tube, card stock, and tape. The rockets were launched using a tire pump and PVC tubing with a valve. The tire pump added air into the PVC pipes just like it would fill a bicycle tire. When the blue valve on the launching pad was closed, the air could not escape, increasing the air pressure inside the PVC pipes. Air naturally wants to maintain balanced pressure, so the high pressure children built up inside the pipes would move as quickly as possible to areas with lower pressure. The end of the PVC pipe had a threaded nipple that
acted as an adjustable launch perch. When the valve opened, the air was quickly forced out of the pipes, creating a gust of air flow. Children witnessed the release of pressure, which resulted in a blast of energy, pushing the rockets forward. Big kids also learned, according to Newton’s 3rd Law of Motion (for each action there is an equal and opposite reaction), the force of the air moving into the rocket and back out propelled the rocket forward. Furthermore, they discussed how the trajectory, or flight path, of the rocket was determined by the angle of the nipple, or launch perch. The next station continued to emphasize engineering, design, and motion.

The second big kid station, designing and building balloon-powered LEGO cars, was mechanical engineering and physics in action. The inflated balloon was full of potential mechanical energy because there was energy stored in the expanded elastic of the balloon. When children let the air escape from the balloon, the potential mechanical energy transformed into kinetic mechanical energy. Children learned the car moved because there was a force acting upon the car. According to Newton’s 3rd Law of Motion (for each action there is an equal and opposite reaction), the force of the air moving in one direction created an opposite force that propelled the car forward. As Newton’s 1st Law of Motion, the car stopped moving because another force; friction between the wheels and floor, acted upon it.

The third station continued working with the balloon-powered cars. The car children built was their first model. Like engineers, children learned new information from each test: their own cars and watching other cars test. Engineers make many changes, or modifications, based on the information they get from tests. Children learned
the new designs are called iterations. They also learned engineers may go through hundreds of iterations before they get the model that fits their needs. Facilitators emphasized this is NOT failure, but a part of the engineering design process. This is how they make their designs better. The final station also engaged children in the engineering design process.

The fourth station had children build a traditional paper airplane, or glider, and a hoop glider. This activity highlighted why forces make it possible for paper airplanes to glide. Children learned thrust, lift, drag, and gravity are all forces that impact the flight of gliders and airplanes. All of these forces (thrust, lift, drag and gravity) affect how well a given paper glider's voyage goes. The hoop glider worked because of forces too. However, it had an advantage. The two sizes of hoops created balance while the circular shape of the hoops maximized lift. This allowed the hoop glider to remain in the air longer.

Each station was facilitated by two adults: a female in a STEM-related field and a princess from popular culture. Both adults were encouraged to engage with the young females through conversations, interests, and activities related to STEM. For example, a marine biologist worked with STEM Princess Ball attendees to look at the shells of bivalve organisms in order to describe, categorize, and organize them while the mermaid princess discussed the benefits of oceanic biodiversity.

Princesses present at STEM Princess activities were played by high school and undergraduate students who planned to pursue a STEM career. They used the clothing, hair styles, and other physical attributes of princesses from popular culture. However,
they did not embody the traditional princess persona. Instead, STEM princesses engaged in conversations related to STEM, academic success, and future career interests. For example, at one STEM Princess Ball, Cinderella approached a young female dissecting a pumpkin wearing a dress distinctively mimicking her character. She proceeded to discuss which characteristics make pumpkins the largest of the berry family, never once mentioning her dress or appearance.

STEM Princess activities are further female-centered through recruiting women in STEM fields as facilitators. These women are all volunteers who have a personal passion for increasing the representation of women in STEM fields. During the STEM Princess Ball, volunteer facilitators wear their traditional clothing with a princess flair. For instance, a pharmacist wore a full ball gown with a white lab coat over top, and a tiara fashioned out of pill bottles that have been bejeweled. Another facilitator was an environmental scientist who wears her field work garb and a crown of flowers. The goal was to use outward appearance and signs to communicate they are both doers of STEM and distinctively feminine.

The goal of the STEM Princess Ball is to blur the stereotypic narratives that divide princesses and STEM professionals by positioning the princesses and professionals as equally powerful and with the same amount of potential to be successful doers of STEM. The purposeful positioning of princesses, facilitators, and attendees is designed to make a novel figured world where the fantasy of the STEM Princess allows attendees to play with new roles while engaging in conversation and participating in practices specific to STEM. I described the context of the STEM Princess Ball in great
detail because the representation and positioning of females in STEM is pivotal in the world making connected to figured worlds. Figured worlds allow individuals to engage in environments/contexts they may traditionally not be included in. Females in STEM is one example. Participants of the STEM Princess Ball are entering the STEM Princess figured world where they are purposely positioned as privileged participants who are engaged in socially and culturally produced activities.

The STEM Princess Ball has the potential to be a powerful experience for identity development. However, it was only one day for three hours. Identity development occurs over historical time and context as an individual is immersed in worlds (Holland, Lachicotte, Skinner & Cain, 1998). This behooves the question of whether this one-time event would have a lasting influence on participants’ STEM identity development. In an effort to create enduring engagement in the STEM Princess figured world, I created at-home STEM experiences with videos and supplies that extended the figured world from the initial engagement at the STEM Princess Ball into homes through four components. Each component, described in detail below, brought the STEM Princess into the home through videos, supplies, and STEM experiences. The first component of the at-home informal STEM experience included all of the supplies to complete the STEM activity and a detailed instruction sheet for the parent (see Figure 5). The instruction sheet provided step-by-step directions for the at-home STEM experience on one side and an explanation of the STEM content on the opposite side. Two QR codes were embedded in the instructions provided in each at-home experience.
Figure 5. Directions included in at-home STEM Princess experiences.

The first QR code directed the parent and child to a short introduction video. A princess character from popular culture appeared on the video asking the child to join her on a STEM experience. Directions were provided using video clips of other girls three- to nine-years-old completing the experience while a female voiceover provided instructions and asked probing questions. The same probing questions were provided for the parents on the instruction sheet. The second QR code directed the child and parent to the third component of the at-home STEM experience, a short video of a female STEM professional discussing her career and how she uses STEM. In total, the informal STEM
learning experiences took 45 minutes to an hour to complete: two to three minutes for each video, and 30 to 45 minutes for the activity.

All at-home experiences were fully vetted prior to sending them to participants of this study. In a pilot of this study, at-home experiences were sent to 30-90 females ranging from three to nine years. Feedback was collected from parents and children about the approachability and usability of the components. Ten parent-child dyads were contacted by phone after completing each at-home experience in an effort to gather further details on their experiences and suggestions for improvement. The at-home experiences sent to participants of this study were redesigned and improved based on the findings from the pilot study.

**Participants**

Participants were selected using homogeneous purposive sampling (Patton, 1990). According to Merriam (1998), case studies need to utilize purposive sampling to bind the collective cases. Participants were carefully selected and the study bound by time and context to enable me to make comparisons across cases (Stake, 1995). Inclusion criteria for the participants included: female, five to eight years of age, and White. While I did not investigate race in this study, I did include race in the inclusion criteria to account for the intersectionality of identities. Because STEM identity development is influenced by gender and race among other demographic and situational factors, I chose to study a racially heterogeneous group of participants in an effort to better understand how STEM identity development is influenced specifically by gender. I was acutely aware that the exclusion of children of color created a limitation to this study. Further investigation of
diverse population is necessary to fully understand STEM identity development in concert with the STEM Princess figured world.

Exclusion criteria included: male, younger than five and older than eight, and children of color. Although male children were welcomed to attend events and participate, they were not included in the recruitment pool in the study. This was because the present study sought to understand how the figured world created by the STEM Princess and participation in the environment influenced the way females engage in and perceive STEM. Children younger than five and older than eight are in developmentally different phases of identity development excluding them from the study. Finally, children of color were excluded in an effort to limit intersectionality of identities. I hope to repeat this study with different racial groups.

Figure 6 depicts the recruitment process for both cases. The left side of the graphic depicts the recruitment process for the STEM Princess case (STEMP) while the right side is the recruitment process for the Business as Usual case (BAU). Recruitment for the BAU case happened using contacts from another study while recruitment for the STEMP case was related to STEM Princess Ball registrations. A total of 98 children registered to attend the STEM Princess Ball with 93 actually attending. Three registered children were excluded because they are my children. Two children identified as male. At the time of the STEM Princess Ball, 32 children were under five years or not yet in formal school. Another nine children were over eight years of age. Of the 47 participants remaining, 13 identified as a racial category other than White, leaving a final selection
pool of 34. Participants in group one were purposely selected from children who attended the STEM Princess Ball. Participants in group one needed to meet the following criteria:

- They had not engaged in any STEM Princess Balls prior to beginning this study.
- Their parents were willing to complete the at-home experiences with the child.

After comparing the registration list to the records from previous STEM Princess events, I found seven of the remaining 34 children had not attended any previous STEM Princess activities.

![Diagram showing recruitment process for STEM Princess and Business as Usual case.](image)

*Figure 6. Recruitment process for STEM Princess and Business as Usual case.*

Participants in the BAU case were recruited using snowball sampling from a related study of children three- to five-years-old. In the related study, I assessed the conceptions preschool-aged children held about the STEM community. Participants were tested in three preschools where parents consented to the assessment. The parents of participants from that study were contacted to recruit the older siblings, ages five- to eight-years-old,
to participate in this study. A total of nine families were contacted with six agreeing to participate. Participants in group two needed to meet the following criteria:

- They had not engaged in any STEM Princess Balls prior to beginning this study.
- Their parents were willing to complete the interviews with the child.

After contacting parents, nine of the children remained in the selection pool. All seven children and parents from STEMP case initially agreed to participate. However, after the initial interview, one parent decided to not participate. The data from this participant was not included in the study. Eight of the nine children and parents from BAU case initially agreed to participate. However, two parents never returned my requests to schedule an initial interview. I interpreted this as a refusal to participate. In total, 12 children and their parents agreed to participate in the study.

The 12 participants were divided into two groups with six children each. The STEMP case engaged in the figured world of STEM Princess. In addition to attending an intensive three-hour informal STEM experience, the STEMP case received an at-home STEM experience every 14-20 days in the mail for four and a half months immediately following The STEM Princess Ball, for a total of five unique informal STEM experiences at home (See Appendix B). The BAU case did not receive the at-home STEM experiences during the ten weeks following the STEM Princess Ball.
Table 1. Participants information by case.

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Age</th>
<th>Grade</th>
<th>Siblings</th>
<th>Mother Education</th>
<th>Mother Occupation</th>
<th>Father Education</th>
<th>Father Occupation</th>
<th>Monthly STEM Engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STEM Princess Case</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harper</td>
<td>7</td>
<td>2</td>
<td>2</td>
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<td>Home-maker</td>
<td>BS Ag Science</td>
<td>Insurance Sales</td>
<td>0-1</td>
</tr>
<tr>
<td>Rose</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>BS Nursing</td>
<td>Home-maker, Home School</td>
<td>BS Accounting</td>
<td>Accountant</td>
<td>5+*</td>
</tr>
<tr>
<td>Carrie</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>BS Comp. Science</td>
<td>IT Manager</td>
<td>BS Ag Science</td>
<td>Seed Genetics</td>
<td>2-4</td>
</tr>
<tr>
<td>Hannah</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>BA Education</td>
<td>Preschool Teacher</td>
<td>BS Engineering</td>
<td>Ag Manufacturing</td>
<td>2-4</td>
</tr>
<tr>
<td>Eden</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>JD</td>
<td>Lawyer</td>
<td>JD</td>
<td>Utilities Development</td>
<td>0-1</td>
</tr>
<tr>
<td>Reagan</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>BA Social Services</td>
<td>Parole Officer</td>
<td>BS Business</td>
<td>Insurance Adjustor</td>
<td>2-4</td>
</tr>
<tr>
<td><strong>Business as Usual Case</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ginny</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>BA Business</td>
<td>Homemaker, PT Marketing</td>
<td>MA Comp. Science</td>
<td>IT Manager</td>
<td>5+</td>
</tr>
<tr>
<td>Bailey</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>MS Counseling</td>
<td>High School Counselor</td>
<td>BA Business</td>
<td>Banker</td>
<td>2-4</td>
</tr>
<tr>
<td>Ingrid</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>BA Accounting</td>
<td>Accountant</td>
<td>AA Business</td>
<td>Electrical Sales</td>
<td>0-1</td>
</tr>
<tr>
<td>Emily</td>
<td>6</td>
<td>1</td>
<td>1</td>
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<td>Home-maker</td>
<td>MS Nursing</td>
<td>Nurse Practitioner</td>
<td>0-1</td>
</tr>
<tr>
<td>Penny</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>BS Health and Wellness</td>
<td>Web Developer</td>
<td>BA Business</td>
<td>Landscape Design</td>
<td>2-4</td>
</tr>
<tr>
<td>Remi</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>BA Marketing</td>
<td>Marketing</td>
<td>BA Business</td>
<td>Mortgage Broker</td>
<td>2-4</td>
</tr>
</tbody>
</table>

*This participant is homeschooled. Her mother included all STEM-based learning at home, including those that are a part of their homeschool curriculum and activities.*
In Table 1, I share information on each participant. The two cases were bound by demographics beyond sex and race. All participants resided in suburban areas of the same metropolitan area in the Upper Midwest region of the United States. Further, the children and families all self-identified as middle class and lived in nuclear families. In other words, the children from both cases had similar contextual surroundings. It is significant to note this is not a fluke. Marriage can be used as a proxy for social class (Holden & Smock, 1991). The advantages of White nuclear families are directly connected to their social class and zip code.

It is important to note my own children do participate in STEM Princess activities and events. They were not included in the selection pool for this study. However, nine of the 12 participants were acquainted with my children through school and extracurricular activities. Through the proxy of my children, I was acquainted with five of the participants. Still, these relations were not well-established or familiar. To this point, prior to beginning the study, I needed to introduce myself and build rapport with each child.

**Data Collection**

Data was collected from children and parents throughout the study. The purpose of the parent data was only to triangulate the data from the children. Parent responses to the same or similar interview questions provided space to compare and contrast children’s responses, as young children occasionally respond spontaneously or fictitiously in new environments (Punch, 2002b). Data collection occurred over a 20-week period. Table 2 provides an overview of the schedule for completion of data
collection. Although Business as Usual case did not attend the STEM Princess event or receive the at-home STEM experiences, they followed the same data collection schedule.

*Table 2. Data collection schedule.*
Stage one of data collection occurred one week prior to the STEM Princess Ball, the initial exposure to the STEM Princess figured world. Parents of children in both cases also completed a demographic survey online during this period. Initial interviews were conducted with all twelve participants three to seven days prior to the STEM Princess Ball. Children engaged in photo sorts and drew a person in STEM as a part of the interview process. After each interview, I created memos to guide the direction of my study. I constantly compared my memos and participants’ answers to form more detailed interview protocols for future interviews.

Stage two of data collection occurred immediately after the STEM Princess Ball. Semi-structured interviews were conducted with all twelve participants. Children in STEM Princess case were interviewed for the second time immediately after the event. Children in the Business as Usual case were interviewed for the second time three to four days after the event. Interviews used the extended protocol, photo sorts, and the “draw a STEM person” activity. After each interview, I continued to create memos to guide the next phase of my study.

During stage three of data collection, children in both cases completed a semi-structured interview and engaged in the object/place photo sorts. After the STEMP case completed at-home experience four, children in both cases completed an extended semi-structured interview, engaged in photo-elicited interviews related to both photo sorts, completed the Pick-a-STEM-Person Tests (PASPT), and drew a person in STEM. After at-home experience four, children were asked to draw a boy and a girl, and then described the people in their drawings. I initially placed this in the extended interview
following at-home experience three. However, I chose to move this to a different interview to avoid participant fatigue as the estimated engagement was over 30 minutes after at-home experience three.

Following the fifth and final at-home experience, children engaged in the same extended interview, photo-elicited interviews related to the both photo sorts, completed the PASPT, and drew a person in STEM. Parents were also interviewed after the extended child interviews for triangulation purposes.

There were occasions when I was not able to complete interviews with children due to unforeseen circumstances. Participants experienced two deaths in their families, as well as seasonably poor weather that impacted the interview schedule. Two of the missed interviews were extended sessions which were moved to the next scheduled interview. Details about each data source are provided in the following sections.

**Demographic Survey**

Prior to the initial interview, parents were sent a demographic survey (see Appendix C). The 13-item survey gathered information about the children including: sex, age, race, grade in school, parent education levels, parent careers, and details on STEM engagement and interest. The survey included multiple dropdown menus to expedite its completion. On average, the survey took parents 10-15 minutes to complete. I used this information to ensure continuity and similarities between my cases.

**Child Interviews**

I developed a semi-structured interview protocol to gather information related to each child’s STEM identity (See Appendix D). This protocol was used in every
interview. While most questions were the same across participants, the semi-structured interview allowed me to ask follow-up questions and explore interesting answers to the structured questions. The parenthetical phrases following each question correlate with the topics of my research question and sub-questions. Interviews using these questions lasted 20-30 minutes.

**Child Extended Interviews**

I developed a second semi-structured interview protocol (See Appendix E) to gather more detailed information related to participants’ STEM identities as well as their interests and conceptions outside of STEM. Extended interviews were broken into two parts: questions not related to STEM and questions related to STEM. This is purposeful. I placed all of the non-STEM related questions in the beginning, as I did not want the STEM-related questions and answers to alter the non-STEM related questions. When conducting interviews with young children, presenting a topic or inserting a word has the power to lead the child toward a particular answer or the answer they believe the adult wants to hear (Irwin & Johnson, 2005). First interviewing children about topics not directly related to the topic of the study helps maintain neutrality of their answers (Docherty & Sandelowski, 1999). This is why I chose to ask about their conceptions of sex and non-STEM interests prior to asking about STEM-related topics. Extended interviews were completed with children three times and lasted 30-45 minutes.

**Parent Interviews**

Parents were interviewed at the same time as their child engaged in the extended interviews. This protocol was used in every interview (See Appendix F). I developed a
semi-structured interview mirroring the child interview protocol. Question responses were used to triangulate the answers their children provided. While most questions were the same across participants, the semi-structured interview allowed me to ask follow-up questions and explore interesting answers to the structured questions. Interviews using these questions lasted 10-15 minutes.

**Drawings**

Drawings allow children to express their perspectives (Fargas-Malet, McSherry Larkin & Robinson, 2010). When coupled with follow-up questions and interviews, drawings can prompt rich descriptions of objects, people, places, and experiences (Driessnack, 2005; Leonard, 2007). Drawings also help children reflect on the drawing prompt, organize their thoughts, and incorporate details into their narratives (Darbyshire, MacDougall & Schiller, 2005). Drawings can also be a source for gathering information about children’s conceptions and perceptions by analyzing differences and similarities between the drawings and descriptions (Darbyshire, MacDougall & Schiller, 2005; Driessnack, 2005). In this study, drawings were used to gather data on children’s conceptions of the STEM community, their sense of belonging in STEM, and sex.

**Draw a STEM Person.** Based on Chambers’ (1983) “Draw a Scientist Test,” this activity gathered data on participants’ conceptions of the STEM community. Theoretically, their drawings should match the stereotypic images of scientists, technology-based professionals, engineers, and mathematicians. Children received a white piece of paper and a pencil to complete their drawing (See Appendix G for protocol). Children were asked to draw a STEM person before and after the STEM
Princess Ball, after the third at-home experience, and at the conclusion of the study. These drawings were used to triangulate the other data conceptualizing parents’ STEM identities. After completing their drawings, participants were asked follow-up questions (See Appendix H). The follow up questions were central to analyzing participants’ drawings. In an effort to limit my subjectivity during analysis of the drawings, I also asked participants clarifying questions about their drawings. Instead of asking questions such as, “Is this a girl?” I pointed to the drawing and said, “What is this?” or “Tell me some more about this.” Although parts of the drawings may have appeared obvious to me, I asked for clarification to ensure the analysis was as objective as possible.

**Draw a Boy and Girl.** Similar to the “draw a STEM person” activity, this activity gathered data on participants’ conceptions of sex and related appearance. Children received a white piece of paper and a pencil to complete their drawing. Children were asked to draw a boy and girl after the fourth at-home experience (See Appendix I for protocol). These drawings provided details and physical characteristics participants associate with sex and gender. After completing their drawings, participants were asked the following question (See Appendix J). Like the Draw a STEM Person analysis, the follow up questions and discussions about their drawings helped reduce the subjectivity in the analysis of this data.

**Photo Sorts and Photo Elicited Interviews**

Children completed two photo sorts: objects and places (See Appendix K), as well as people (See Appendix L). The use of photo prompts when interviewing children stimulates children’s responses and can elicit more in-depth answers (Fargas-Malet,
Photo sorts and associated interviews can help children tell stories about themselves that include feelings and talking about sensitive topics (Clark, 2005; Hill, 1997; Thomas & O’Kane, 1998). In particular, the photos used in this study were presented to determine if children associated characteristics similar to them, such as gender, with STEM objects, as this is an important part of their sense of belonging. Photos were used in this study as a way for children to communicate their stereotypes associated with STEM and sex, as well as a prompt for discussing these associations.

Children completed the photo sort of objects and places with each interview. Children were also asked to provide their rationales for selecting whether objects and places were for boys or girls over the course of the final five interviews. Finally, children were asked to identify if they thought the images were objects and places that related to STEM or not and to describe why. The data from the photo sort provided information about the unspoken or hidden connections participants may have between STEM and gender. The photo-elicited interviews gathered data about how participants determined which photos of people, places, and things were related to STEM.

**Objects and Places Photo Sort and Interview.** Objects and places were selected for the photo sorts using language from solicitations, proposals, and programs related to the National Science Foundation’s STEM initiatives (e.g. NSF 17-590 Improving Undergraduate STEM Education: Education and Human Resources (IUSE: EHR), NSF 18-084 Dear Colleague Letter: STEM Education for the Future; NSF 18100 Accelerating Discovery: Educating the Future STEM Workforce (AD)), as well as the characteristics
from the Draw-a-Scientist Test and Draw-an-Engineer Test checklists (Finson, Beaver & Cramond, 1995; Knight & Cunningham, 2004). Examples of objects and places included are a lab coat, Legos, robots, national park, fractal art, a ruler, a hard hat, etc. (see Figure 7).

Some objects were included more than once. For example, robots were mentioned in multiple NSF documents. However, when I searched for “robot” using Google, a huge variety of robots were depicted: human-like, Spheros, toys, and industrial (see Figure 8). I chose to create subcategories in these cases and included a photo of each subcategory, or type of robot. I compiled a total of 32 photos (See Appendix K).
Photo sorts designed for young children should be concise and require a short amount of time to match their attention span (Punch, 2002b). When piloted, children started to provide patterned responses without meaning and lose focus after 25-30 photos. To reduce participant fatigue during interviews, I decided to divide the object and places photo sort into two sets: set A and set B (see Figure 9). I made the sets similar by first categorizing the photos. For instance, one photo showed Yosemite National Park and another depicted a farm field (see the middle, right photos of each set in Figure 9). I categorized these as the outdoors and divided them into different sets. Similarly, I divided up the robots discussed previously to distribute them between the two sets. Each set was presented to children over four interactions: set A after first and third at-home
experiences, set B after second and fourth at-home experiences. This means the complete battery of images from the object and places photo sort were presented twice.

\[ Set \ A \qquad Set \ B \]

\[ Figure \ 9. \ Dividing \ photos \ of \ STEM \ objects \ and \ places \ into \ two \ sets. \]

NOTE: Images are positioned to highlight how similar objects and places were separated to create two similar sets of photos.

Photos were printed in color and presented in random order. Participants were given the following prompt: “I am going to show you some pictures. I want you to tell me if you think these objects and places are for boys, girls, or both.” Additionally, the photo-elicited interview was only done once for each photo set of objects and places: set A after experience three, and set B after experience four (see Appendix M).

**People in STEM Photo Sort and Interview.** Photos included in people in STEM sort were from the Pick-a-STEM-Person Test (PASPT) and varied on three binary dimensions of gender, race, and scientific context. A total of eight photos were used, each held constant the criteria of age (25-35 years), looking at the camera, smiling, identical size, and free to commercially use (See Table 3). Sex was operationalized in photos using
phenotypical and cultural characteristics that could be readily observed by young children, with females having long hair, soft facial features often including make-up, and clothing traditional to women’s style in the United States. Conversely, males were selected to have short hair, sharp facial features, no makeup, and clothing traditional to men’s style in the United States. The STEM context was defined as an indoor, laboratory setting with recognizable STEM equipment (i.e. flasks, robots, geometric figures, etc.), and included a person wearing glasses, a lab coat, and actively working. Photos with a neutral or “non-STEM” context had individuals in plain clothing in indiscernible backgrounds without any accessories. Race was measured using skin tone and categorized as White or Black.

Table 3. Images with demographic characteristics from the Pick-a-STEM-Person Test.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>White</td>
<td>Black</td>
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<tr>
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<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Neutral Context</strong></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
</tbody>
</table>

All photos are of people with STEM-related careers in real life. Example careers of the person in the photos included aerospace engineer, chemical engineer, biologist,
medical doctor, and physicist. The photo sort was computerized using Qualtrics software and presented as pairwise comparisons in random order. Each comparison started with an audio recording asking, “Which person do you think has a job in STEM?” Prior to beginning the sort, participants were given directions using audio and video. The photo-elicited interview (see Appendix N) was only completed once for photos of people in STEM, after the third at-home experience.

**Data Analysis**

Data analysis is “the process of making sense out of the data. And making sense out of data involves consolidating, reducing, and interpreting what people have said and what the research has seen and read—it is the process of making meaning” (Merriam, 1998, p. 178). Due to the multiple sources and volume of data in a case study design, Merriam (1998), Stake (1995), and Yin (2017) all recommended the use of computer software to code, manage, and triangulate the data. Interviews and recordings were uploaded and codes recorded using Dedoose (Version 8.0.35). The plan for data analysis is described below.

Data were inductively analyzed using systematic data management through reduction, organization, and connection (LeCompte, 2000). An initial code list and definitions were created using a priori coding (Miles, Huberman & Saldaña, 2014) based on the figured worlds framework. Codes were discussed with my advisor to review and were revised as necessary. As other codes emerged from the data, they were defined and added to the codes from the a priori list to create a codebook. Developing a codebook helped the codes remain clear and concise, ensuring this study can be replicated
(Creswell, 2014). The codebook was also used to create reliability. Coding is an iterative process used to link data to the framework of the study and other broader concepts (Saldaña, 2009). The codebook guided the coding of the data, and the data guided the refining of the codebook.

**Coding the Data**

This study had two cycles of coding used to identify themes in the data that addressed the research questions using explanations and examples (Saldaña, 2009). The first cycle of coding employed elemental methods of coding, including descriptive (word or phrase that describes the datum), process (word or phrase that describes an action), and simultaneous (datum requiring two or more codes) coding to interpret the data (Saldaña, 2015). I used initial coding defined by the a priori codes from the figured worlds framework. According to Saldaña (2009), researchers use initial coding to understand the essence of the data and label it. The first cycle of coding reveals natural and deliberate patterns to the researcher.

When all data were initially coded, the first cycle shifted to codifying the data, identifying patterns, and searching for reasons the patterns were present in the data (Saldaña, 2009). I codified the data by categorizing the first cycle of codes to make sure the data was “segregated, grouped, regrouped, and relinked in order to consolidate meaning and explanation” (Grbich, 2007, p. 21). Categories were created using logic and theory to place codes that were similar together (Lincoln & Guba, 1985). The categorized codes began revealing the patterns in the data. According to Hatch (2002), data patterns take multiple forms: similarity, difference, frequency, sequence, correspondence, and
causation. I used these pattern types to begin searching for reasons for the patterns present in the data.

Inter- and intra-rater reliability were established after I completed the first cycle of coding. Walther, Sochacka, and Kellam (2013) advocate for ongoing assessment of quality to mitigate interpretive bias and increase consistency in coding. Inter-rater reliability builds trustworthiness in the study’s findings by ensuring the codes are clear and can be reliably applied to the data. I provided my codebook, a list of codes with definitions, to one of my committee members. We independently coded three transcripts of initial interviews and another two after the second at-home experience. We also coded two drawings. I then re-coded each of these sources a second time one week later for the purpose of intra-rater reliability.

I calculated inter- and intra-rater reliability after all coding was complete. Miles and Huberman (1994) suggest 95% of codes should have inter- and intra-rater reliabilities with agreement between coders at 80% or higher. To calculate rater reliability, I used the formula from Miles and Huberman (1994):

\[
\text{Reliability} = \frac{\text{# of agreements}}{\text{# of agreements} + \text{# of disagreements}}
\]

Inter-rater reliability was 96%. Any disagreements were discussed and resolved to come to 100% consensus (Walther, Sochacha & Kellam, 2013). I also modified and clarified the definitions in the codebook during this process.
I calculated intra-rater reliability using the same formula. However, instead of using the number of agreements and disagreements between raters, I used the number of agreements and disagreements between the two times I coded the same transcripts and drawings. Intra-rater reliability was 98% on the drawings and 96% on the transcripts.

The second cycle of coding was the iterative process of qualitative case study analysis. Using the refined codebook (see Table 4) from the inter-rater reliability, I re-coded the data. This does not mean I started fresh. According to Saldaña (2012), the second cycle of coding was rearranging, relabeling, or dropping the codes from the first cycle in order to reshape, reform, or create new categories. The process of iterative analysis was essential to consider the data equitably by converging the data into a case (Stake, 2013). Furthermore, clearly defined, well-thought-out categories are imperative because the comparing and consolidating of categories moves the study toward conceptual understanding that will allow me to make assertions based on the data (Richards & Morse, 2007).

Finally, I triangulated the multiple sources of data to increase the validity of the analysis (Patton, 2002; Yin, 2017). For instance, I triangulated the photo sort responses and drawings from the “draw a STEM person” activity to conceptualize the initial conceptions of STEM held by the participants while descriptions of someone in a STEM career were used to triangulate their selections on the PASPT.
Table 4. Codebook.

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal STEM learning</td>
<td>Structured experiences and activities that occur within the school day and/or with teachers. NOT: child-to-child or peer interaction. Does not include unstructured, self-led activities.</td>
</tr>
<tr>
<td>Informal STEM learning</td>
<td>Structured experiences and activities that occur outside the school day and/or with teachers. NOT: in the home or with family. Does not include STEM Princess. Does not include unstructured, self-led activities.</td>
</tr>
<tr>
<td>Home/family learning</td>
<td>Structured and unstructured experiences and activities that occur within the home and/or family. NOT: child-led play or activities. Does not include unstructured, self-led activities.</td>
</tr>
<tr>
<td>Media influence from STEM</td>
<td>People, places, things, and ideas children reference from photographs, TV, movies, radio, advertisements, YouTube, and other media. NOT: media related to STEM Princess activities.</td>
</tr>
<tr>
<td>STEM Princess</td>
<td>Structured experiences and activities in the STEM Princess figured world. Includes at home experiences, day camp, videos, role models, careers, and connections to princesses or content beyond the experiences and activities themselves.</td>
</tr>
<tr>
<td>Conceptions of STEM</td>
<td>Ideas, opinions, and beliefs about STEM. Objects, people, and activities that are specific to STEM. NOT: Ideas and beliefs about STEM related to self or ability.</td>
</tr>
<tr>
<td>Agency in STEM</td>
<td>Expressed (verbal and action) capacity to coordinate skills and behaviors related to success in STEM experiences and activities. Focus connections of doing. NOT: beliefs or interests.</td>
</tr>
<tr>
<td>Self-efficacy STEM</td>
<td>Statements and behavior that indicate a belief the child is able to be successful in STEM-related endeavors. Includes mastery and vicarious experiences as well as feedback (self and social) and physiological reactions (excitement, happiness, anxiousness, dread, etc.) Focus on beliefs. NOT: examples of succeeding in STEM activities. This is agency.</td>
</tr>
<tr>
<td>Sense of belonging in STEM</td>
<td>Match or mismatch between physical, social, and cultural norms of the child and STEM or STEM community. Related to career preferences, perceptions of being good/bad at STEM, conceptions of the STEM community, comfortability with members of the STEM community, and the ability (or lack thereof) to connect self with established members of the STEM community. NOT: beliefs or ideas related to personal skills or capacities related to STEM.</td>
</tr>
<tr>
<td>Interest</td>
<td>Wanting to know or learn more about STEM or STEM-related careers. Excitement, curiosity, and attention related to STEM.</td>
</tr>
<tr>
<td>Embodiment of STEM identity</td>
<td>Depiction of self (verbal or print) as a member of the STEM community or doing STEM. Key is doing or belonging. NOT: just beliefs or an expression of capacity</td>
</tr>
<tr>
<td>Conceptions of STEM Community</td>
<td>Ideas, opinions, and beliefs about who is good and/or participates in STEM. Includes physical and behavioral characteristics as well as stereotypes. NOT: Ideas and beliefs about STEM the subject.</td>
</tr>
<tr>
<td>STEM careers</td>
<td>Discussing STEM careers: interest in, perception of, types, examples, etc.</td>
</tr>
<tr>
<td>Role models STEM</td>
<td>Individuals with influence over how the child conceives of the STEM community or STEM as a subject. Includes STEM princess. Can be positive or negative. May also be STEM Princess, school or family.</td>
</tr>
<tr>
<td>Conceptions of gender</td>
<td>Behaviors, roles, physical appearance, interests, and ideas related to males and/or females. NOT: specific to self.</td>
</tr>
</tbody>
</table>
Constructing the Cases

Data were analyzed holistically (Yin, 2017). I constructed the cases by creating detailed descriptions of the histories, experiences, conceptions, and identity development using a chronological approach (Stake, 1995). First, I looked across participants within each case using constant comparison to find recurring themes (Glasser & Strauss, 1967). Using the qualitative analysis features in Dedoose, I created a report connecting themes to participants within each case. Only themes consistent across participants within a case were used to construct the cases. Common themes may be shared by the cases or unique to each case.

Case Study Analysis

In this study, I analyzed the data and compared the findings to the identity formation described in the figured worlds framework. The STEM Princess and Business as Usual cases were compared to each other. To do so, I completed my analysis in two phases using the figured worlds framework to conceptualize the formation of STEM identities over time and context.

Phase One: Identity development over time within cases. I analyzed the participants’ identity development over time during phase one. More specifically, I investigated their conceptions related to STEM as well as the STEM sense of belonging, self-efficacy, and interest across the duration of this study. In developing each case, I analyzed the identity development of each case over time. This was done comparing the participants’ conceptions, sense of belonging, self-efficacy, and interest across the three stages of this study: before all STEM Princess participation, after the STEM Princess
Ball, and after the STEM Princess at-home experiences. I focused my analysis on both consistencies and changes. Particular attention was paid to themes that shifted over the three stages of the study. The patterns revealed in the themes were significant to the process of STEM identity development. The case narratives were attentive to the conflict, integration, and dialog that are hallmarks of authoring a new identity according to Holland, Lachicotte, Skinner, and Cain (1998). This phase of analysis provided an overarching conceptualization of the process of identities in practice in the STEM Princess case and the Business as Usual case.

**Phase Two: Differences and constancies between cases.** I compared the STEM Princess and Business as Usual cases stated in my research questions during the second phase of analysis. I compared and contrasted the two cases by investigating the points of congruence and departure across cases. I organized this process through analyzing each stage of the study followed by the overarching experiences. The patterns of identity development constructed in phase one were central to the contrasts and comparisons in phase two. The second phase of data analysis sought to understand if the identities in practice of the STEM Princess case were the same as to the Business as Usual case. The cross-case comparisons provided insight into the influence participating in the STEM Princess figured world did and did not have on the STEM identity development of young girls. This phase also involved looking at alternative propositions. Specifically, the aim of this phase of analysis was understanding if any differences are related to participating in the STEM Princess figured world.
Tensions and Unresolved Complexities

Several points of tension and discontinuity surfaced during data collection and analysis. First, one of my interview questions asked children if they were comfortable talking to a person in STEM. The girls responded they were not. However, this was because they were feeling tension between talking to a STEM professional with the protocols of stranger danger. In order to collect accurate data about their sense of belonging in STEM, I added the clause “and you know they are a safe person” to resolve the tension and get responses that reflected what I was attempting to understand.

The greatest tensions I experienced in data collection were elements that required parent participation. On one hand, parents agreed to participate in interviews and the STEMP parents agreed to also audio and video record their child completing the STEM Princess at-home experiences. On multiple occasions, parents requested their interviews not be audio or video recorded. One mom claimed this was because “I look like a disaster and haven’t even done my hair or make up” (Eden’s Mom Interview 5, November 13, 2018). However, parents also prefaced many answers with “Don’t judge me” (Eden’s Mom Interview 5, November 13, 2018) or followed responses with “I haven’t even thought about that. Is that bad?” (Harp’s Mom Interview 7, February 3, 2019). This indicated parents were uncomfortable with the interview process and concerned about being judged. The tension between agreeing to participate, yet feeling self-conscious, led to missed opportunities for collecting interview data. I resolved this by taking field notes and recording memos of my experiences.
Unfortunately, the tensions with parent participation carried over into the audio and video recordings they were asked to conduct as the parents and children were completing the at-home experiences. On the final three STEM Princess experiences, parents were asked to video and audio record them completing the at-home STEM experiences with their child. They were provided a recording device as well as a microphone. I gave instructions on how to use the devices and confirmed that the parents were comfortable before leaving the devices. My intent was to use the interactions and conversations in the recordings to understand the implementation of the STEM Princess experiences and STEM identity development happening across the figured worlds of STEM Princess and home. The recordings would have also provided data how parents were engaging with their child during the experience as their interactions have the potential to mediate or moderate their child’s participation in the STEM Princess figured world.

Like the interviews, parents consistently made excuses for why the recordings failed. In one case, a mother did not want to use the provided device but ran out of memory on her own device, leaving me with clips and highlights of the at-home experience. In another case, the mom said the household was noisy and chaotic, so she stopped the video because she did not think I would want to watch a video like that. I attempted to reassure parents I was not evaluating their STEM knowledge or parenting practices. I was surprised parents were willing to participate in the study and not confident with being recorded. I ultimately failed to resolve the tensions parents were
experiencing. Despite my best efforts, I was unable to collect useful recordings from parents, and this data was dropped from the study.

**Validation of Responses**

I interviewed each mother at least once asking the same questions I asked their daughters. The STEM Princess participants’ mothers confirmed their daughters’ answers to questions. Statements related to their daughters’ STEM self-efficacy and sense of belonging were nearly identical. Mothers used their conversations with their daughters to answer the questions noting, how their daughters talked about or expressed being good at STEM. Mothers substantiated their daughters’ interest in STEM and STEM activity describing what they like to do. As a whole, the mothers verified their daughter’s answers as accurate.

One discrepancy surfaced within several mother-daughter dyads: career interest. Children provided a variety of careers they were interested in without any suggestion of STEM. Later, I asked again about interest in careers specifically related to STEM. The second prompt was not a surprise to the mothers. However, the first prompt about careers did yield some surprising answers from their daughters like Laura, Hannah’s mother, who remarked her daughter’s answer “was a new one. She’s never mentioned wanting to be [that]” (Hannah’s Mom Interview 7, February 8, 2019). I asked a follow up question in these situations: How often do you talk to your daughter about future careers and what she may be interested in pursuing? Every mother responded similarly: discussing careers with their daughters was neither something they did at home nor did they feel like they needed to at such a young age.
Any confusion or gaps in the interview data from participants were addressed through parent interviews. I kept detailed memos after every interview and constantly made note of changes or points of interest during interviews. When children expressed a major change or new conception, I made note of it in a memo. I used these memos to ask pointed questions to parents of these children to gather additional information about potential experiences or interactions the child may have had during the same period. This helped me better understand and rationalize any discontinuities in the data.

**Conclusion**

The cases in this study are valuable because they provide promising insights about how the field can influence the STEM identity development of young girls. The collective case approach addresses the complexity of STEM identity development framed by figured worlds. In particular, the methodology used was designed to conceptualize the ways in which the social and cultural interactions and positioning of young girls in the STEM Princess figured world contributed to their identity development.
CHAPTER 4: FINDINGS

My data analysis and coding structure were situated in the Figured Worlds Theoretical Framework to understand how the STEM identity development of girls ages five to eight years is influenced by the figured worlds in which they engage. More specifically, I conceptualized STEM identity development using the lens from Holland, Lachicotte, Skinner, and Cain (1998): a process of self-authoring involving interests, self-efficacy, sense of belonging, and embodiment. I used the lens of figured worlds to answer the following research question: How are the STEM identities of White girls ages five to eight years influenced by female-centered STEM experiences compared to similar peers without the same experiences? I addressed the following sub-questions to answer my overarching research questions:

- What conceptions do participants have of STEM before and after engaging in all-female STEM experiences compared to peers who do not engage in the same or similar experiences?
- How are STEM sense of belonging and self-efficacy of participants influenced by engaging in all-female STEM experiences compared to peers who do not engage in the same or similar experiences?
- How does engaging in all-female STEM experiences influence the interests of participants compared to peers who do not engage in the same or similar experiences?

Five themes emerged from the data. STEM identity development was influenced by participants’: (a) conceptions of gender, (b) conceptions of STEM and the STEM
community, (c) sense of belongingness in STEM, (d) STEM self-efficacy, and (e) interest in STEM. In this section, I discuss each of these themes within the STEM Princess and Business as Usual cases.

**The STEM Princess Case**

The STEM Princess (STEMP) case includes six participants ranging in age from six to eight years and in first and second grades. All participants were White females from the same geographic area with similar family dynamics. All parents had post-secondary education and considered themselves upper middle class.

The children in this case had diverse experiences with STEM prior to beginning the study. Parents reported children engaging in STEM at home between one and seven times per month with additional experiences during school. This did not include instruction of mathematics and science in the school setting as parents were explicitly asked not report these experiences to avoid conflating the numbers. In addition to school, the children engaged in a variety of informal learning experiences in the past such as visiting a science center, attending a STEM-focused camp or club.

Children were eager, yet trepidatious, to meet with me during the first interview. Each of them answered the door with excitement but said few words as I greeted them. All children picked a dining table or place within eyesight or ear shot of the safety and familiarity of their mothers. I set up my cameras and materials while they peppered me with questions about what I was doing and why. It was an easy ice breaker and allowed for enough time for us to familiarize ourselves with one another before beginning the interview process. Over time, participants were more comfortable with me and the
interviews resulted in longer and more detailed responses. Throughout their engagement in the STEM Princess figured world, they shared information about their conceptions of STEM and the STEM community, sense of belonging, self-efficacy, and interests.

**Conceptions of STEM and the STEM Community**

The conceptions children hold of STEM and the STEM community are pivotal in the process of building a STEM identity. Conceptions of STEM help children determine who is a part of the STEM community and whether or not they belong in that community. Conceptions children hold of STEM include how they define STEM, what it looks like to do STEM, and who is a part of the STEM community.

**Conceptions of STEM.** Children had a developing understanding of STEM during our initial interviews. At first, they were not able to describe STEM, instead they responded they did not know what STEM was when asked. This was significant because a basic definition is an essential building block for conceptions. Since the girls were unsure how to define STEM, I used a prepared prompt (see Appendix O) to explain STEM stood for Science, Technology, Engineering, and Mathematics and STEM may involve solving problems, inventing, and creating new things. This prompt sparked participants to make connections to their previous engagement in STEM. The follow up responses from children portrayed an acquaintance with STEM, yet the delay in their initial response may highlight a weak association between the definition of STEM I provided and their conceptions of STEM. The delayed response may also be due to anxiousness or our unfamiliarity as we had just formally met. Hannah chirped, “Of course I [know what STEM is]. I’ve done that in preschool” (Hannah Interview 1,
October 3, 2018). Carrie, like many of the other girls, just nodded her head after being asked if she understood. Their limited conceptions were evident when they added their own information into a summary or repetition of the prompt like “they build new things. They can make big numbers with math. Scientists can discover new things and technology. They can make new things” (Carrie Interview 1, October 4, 2018). Other children responded similarly to Hannah and Carrie affirming, “I remember that!” (Reagan Interview 1, October 1, 2018) after receiving the prompt defining STEM from me.

After attending the STEM Princess Ball, the STEMP case had a major shift in their conceptions of STEM. The STEM Princess Ball, although short in duration, clarified and enriched the children’s conceptions of STEM. Children did not need prompting or help coming up with a definition of STEM following the STEM Princess Ball revealing engaging in the STEM Princess figured world provided an avenue for the girls to gain greater clarity on what STEM is and looks like. Unlike the initial interview, almost all of the girls indicated STEM was “science, technology, engineering, and mathematics” (Reagan Interview 2, October 6, 2018) without prompting. They added details about STEM as “doing experiments and making stuff like Lego cars” (Eden Interview 2, October 6, 2018) often referencing activities from the STEM Princess Ball.

The girls’ responses were immediate and jovial often using examples from their STEM Princess Ball experience. Their access and engagement in the STEM Princess figured world had situated them into an environment where they could connect STEM to fun. Their tone and excitement was palpable like Rose who simply defined STEM as
“SO MUCH FUN!” (Rose Interview 2, October 6, 2018). Like the initial interviews, however, the girls’ responses continued to be short and lacked elaboration.

The STEMP case continued developing and refining their conceptions of STEM over the course of the study. The most common conception of STEM among the girls was “Science, technology, engineering, and math” (Carrie Interview 3, November 14, 2018). The definitions the girls shared were still limited by their experiences, but developing into a more integrated understanding of STEM that involves “doing experiments” (Eden Interview 3, October 29, 2018), “working with numbers” (Carrie Interview 3, November 14, 2018), “building things like fixing up trains or something” (Hannah Interview 3, October 29, 2018), and “going under cars and trying to fix them” (Harper Interview 3, October 30, 2018). In contrast to the other girls, Eden refused to even try to come up with a definition of STEM and continuously replied “I don’t know” (Eden Interview 3, October 29, 2018).

By the middle of our interviews, the conceptions girls in the STEMP case held of STEM also shifted away from “science, technology, engineering, and math” and thinking in silos such as “if it was science, it would be like experiments” (Carrie Interview 5, December 6, 2018) toward a process and way of doing things such as “never giving up on building stuff” (Carrie Interview 7, February 6, 2019). Instead of using the four silos that make up STEM, the girls shared ideas that painted a much broader conception than what they had started with or had at the end of the STEM Princess Ball. Their conceptions of STEM transformed into “a place where you get to learn… learn from your mistakes” (Eden Interview 6, January 8, 2019). They conceived of STEM as “all sorts of things like
measuring and computer stuff and experimenting stuff and science… and trying again and again and again” (Hannah Interview 7, February 8, 2019).

The conceptions of STEM held by the girls moved from vague and abstract to personal and action-oriented. This conveyed a conception of STEM that once again included a positive connotation and sparked joy. Even Eden, who struggled with a basic definition of STEM a month into the study, started to have stronger emotional connections in her conceptions of STEM. “STEM is awesome” (Eden Interview 7, February 8, 2019) because it included “investigating, going out in nature and exploring more” (Rose Interview 6, January 8, 2019). “It looks really cool… [STEM is] doing a lot of stuff… and figuring out stuff” (Rose Interview 7, February 4, 2019). They held the conception that STEM was fun, exciting, and interesting.

There were direct links to engaging in the STEM Princess figured world at home and positive conceptions of STEM the girls held. Reagan knew STEM was when “you make and try to do new stuff with experiments” because that is what she said she had done in her STEM Princess activities (Reagan Interview 5, November 26, 2018). They also connected these conceptions of STEM from the at-home STEM Princess experiences to other activities in their household “like if [Reagan] was building a shelf with [her] dad, [she] would be building it one by one and step by step” like the direction in the STEM Princess kits (Reagan Interview 7, February 4, 2019). The girls’ engagement in the STEM Princess had broadened their conceptions of STEM and allowed them to see excitement and themselves as a part of how they conceived of STEM.
Conceptions of the STEM Community. Children were asked to “draw a STEM person” to better understand their conceptions of the STEM community. If children were not sure what to do, I rephrased the statement as “draw someone who does STEM.” Their drawings served as a visual of what they were seeing in their imaginations as well as a tool to spur discussion about their conceptions of the STEM community including associations with gender, careers, tools and context.

The girls’ initial drawings and descriptions of the STEM community created a conceptualization of a gender diverse community. Their drawings were closely connected to real people in their lives and the roles they assume even when the person’s connection to STEM was vague or a stretch for the child to explain. The images depicted a variety of individuals that were commonly set within a STEM context and surrounded by objects related to STEM such as computers, science laboratory equipment, and tools (see Figure 10). Two children did not add context to their first drawings but had drawn an image of someone they knew who worked in STEM: a science teacher and a babysitter who is attending nursing school (see Figures 11 and 12).
Figure 10. Hannah’s drawing #1 of a STEM person.

Figure 11. Reagan’s drawing #1 of a STEM person.

Figure 12. Eden’s drawing #1 of a STEM person.
I asked children to tell me about the person in their drawing. Descriptions of STEM people focused on people who “build stuff… do experiments, and they answer questions” (Reagan Interview 1, October 1, 2018). “[Harper] drew an engineer fixing a car. She's using a hammer to hammer down a nail inside the car, and there's smoke coming out the chimney. The tools are in her clothes, on the side” (Harper Interview 1, October 2, 2018). The association of building and fixing was misconceived by many of the girls. Drawings like Harper’s equate engineering to driving and fixing trains and building to mechanics and construction work (see Figure 13).

![Harper’s drawing #1 of a STEM person.](image)
Participants often mixed elements of stereotypes to portray a feminine STEM person. All but one girl drew an image of a female depicted by long hair and stereotypically feminine clothing. They confirmed their people were females when asked. For example (see Figure 11 above), the female STEM figure could be “wearing a dress and maybe high heels ‘cause they work at maybe a fancy place… probably a chemistry lab or something” (Eden Interview 1, October 4, 2018). More specifically, Carrie drew herself because “[she] does math at school” (Carrie Interview 1, October 4, 2018) and another drew me (see Figure 10 above) because her mother had explained I was coming to talk about math, science, and technology (Reagan Interview 1, October 1, 2018). The one figure that did not have a gendered appearance (i.e. wearing a dress, hair in a bun, etc.) was identified as male based on the pronouns the child used (e.g. “He likes to do technology and programming books” (Hannah Interview 1, October 3, 2018)).

Children also used clothing to convey their figure was associated with STEM. Their choices in clothing followed many stereotypes associated with STEM where individuals wear a “lab coat, and sometimes they have goggles. And an engineer wears clothes that are dirty and old” (Carrie Interview 1, October 4, 2018). This means drawings were often mixes of high heels, dresses, lab coats, and STEM supplies to depict a female in STEM. Lab coats, safety goggles, flasks, and construction tools were the most common objects girls included in their drawings to emphasize the connection to STEM.

Similar to their drawings, girls focused on clothing and objects related to their conceptions of STEM when completing the PASPT. Images with people “dressed in all white and goggles on and different tools” (Harper Interview 1, October 2, 2018) were
selected more often because this indicated they “do science and build stuff, and they put it in like a kind of museum for other people to come and see them” (Hannah Interview 1, October 3, 2018). When there was a contrast of two people, one person with STEM-related objects versus someone in a neutral context, children selected images with a STEM context at a rate of 20 to 7. This indicated the STEM context was an important conception the girls in the STEMP case held about the STEM community.

Although not as drastic as the STEM versus neutral context preference, the difference indicated the girls unconsciously preferred females over males. When context and clothing were missing on both individuals, girls admitted “[they] just guessed” (Harper Interview 1, October 2, 2018). Furthermore, none of the children mentioned gender as a factor for their selections. When there was a contrast of a male versus female, children selected images with females at a rate of five to three.

Participants in the STEMP case initially described the people in the STEM community using examples of persons with whom they were familiar with personally or through media. When referencing a personal relationship, their conceptions of STEM activities were more limited. For example, Hannah described her grandmother who is “a nurse. She likes to do stuff from her iPad too” (Hannah Interview 1, October 3, 2018). However, when asked about others, Hannah did not know what things they did in their jobs or what activities they may participate in.

In other interviews, children had conceptions of the tasks that a person may complete as a STEM profession because they were similar to what they did in school, yet they were not sure of the careers that might complete the tasks they listed. For example,
Eden noted, “They work at math, kinda like us because we go to school and we do math. And they might do science, and they might do chemistry… They really like to figure out what stuff is going to do or do in the future or what happened in the past” (Eden Interview 1, October 4, 2018). However, she did not discern which STEM careers those tasks were related to such as an engineer or accountant. Similarly, Carrie thought “[STEM professionals] can build new things. They can make big numbers with math,” but did not know which careers those descriptions matched (Carrie Interview 1, October 4, 2018). The tasks and duties described were never connected to a specific job such as engineers build stuff. Carrie recognized “scientists can discover new things and technology. They can make new things” (Carrie Interview 1, October 4, 2018).

Their conceptions of the STEM community and STEM jobs were closely affiliated with the tools, clothing, and settings they had seen in school, books, media, and other photos as well as their drawings. Children’s drawings and selections of images on the PASPT matched the tasks the girls envisioned as STEM careers because “[t]hey build stuff. They do experiments. And they answer questions… They have a science coat, and they have science goggles, and they have stuff in their pockets” (Reagan Interview 1, October 1, 2018).

The STEMP case drew a STEM person for the second time in less than 10 days immediately after participating the STEM Princess Ball. Although the drawings were created within a short timeframe, none of the girls repeated their initial drawings portraying a change the conceptions the girls held of the STEM community and what it meant to do STEM. Two of the girls provided drawings with similar backgrounds but
different people. Harper, for example, drew the same factory setting from her first drawing (see Figure 14) as the background but replaced her mechanic with a scientist doing an experiment (see Figure 15). The drawings depicted refined conceptions of the STEM community that reflected what they had experienced at the STEM Princess Ball. In the first drawing, there was a mechanic that was hammering a car with a factory in the background. In the second drawing, the STEM person was wearing a lab coat adorned with a test tube and safety goggles while using a flask and working at a lab station with a factory in the background. When asked about her drawing at the STEM Princess Ball, Harper stated “[she] is making potions” like they did during the event (Harper Interview 2, October 6, 2018). It is unclear why she included the factory background. However, it showed her conceptions of STEM and the STEM community were influenced by the STEM Princess Ball and evolving as she engaged in the STEM Princess figured world.
Three children drew STEM people based on specific individuals they interacted with at the STEM Princess Ball. The drawings and descriptions did not display a different conception of the STEM community when compared to the initial drawings. However, the second round of drawings showed an expanded conception of who was a part of the STEM community. For example, Carrie initially drew a scientist with a lab coat and safety goggles working in a lab (see Figure 16). The second image (see Figure 17) contained the science equipment and lab from the first drawing but replaced the clothing on the figure with medical scrubs. Carrie stated “she has those green things on like [her group leader]” (Carrie Interview 2, October 6, 2018). Like Harper, Carrie carried over items from her first drawing to her second. She added a flask into her second drawing even though it did not fit the new schema. This was true of the other two children who drew individuals they engaged with during the STEM Princess Ball. The interactions with a new role model and exposure to a new STEM career were powerful influences on their conceptions of the STEM community. They were trying to integrate their existing conceptions with their new experiences.

![Figure 16. Carrie’s drawing #1 of a STEM person.](image16)

![Figure 17. Carrie’s drawing #2 of a STEM person.](image17)
Rose’s drawing was an interesting outlier with her changes. Her initial drawing was of a scientist in a lab. It included flasks, test tubes, and a female wearing a lab coat and glasses (note: Rose’s first drawing is not included because the child refused to relinquish her drawing because she wanted to keep it). Rose described the scientist in her second drawing as “making new stuff using chemicals” (Rose Interview 2, October 6, 2018). Like her first drawing, Rose’s drawing after the STEM Princess Ball (see Figure 17) featured a female scientist. The second drawing had more items on the lab table compared to her first drawing which now included artifacts from biology and space science as well as a computer and several tools for building and measuring. Her first drawing had a lab that featured a random assortment of science tools and equipment without being sectioned into science disciplines. In other words, instead of changing the person, Rose changed what the person was doing and studying based on what she did and learned about at the STEM Princess Ball. “[People in STEM] do lots of stuff and have to know all about it to be good at their jobs. It’s super hard, but really fun” (Rose Interview 2, October 6, 2018). Her conception of the STEM community was evolving.

Figure 18. Rose’s drawing #2 of STEM person.
A growing conception of the STEM community was carried over into how the girls in the STEMP case described people who were good at STEM. Each child eluded to someone who was good at STEM as being diverse in their skill set and needing to try over and over again to succeed. Because one of the learning goals for the STEM Princess Ball was related to the engineering design process and the benefit of multiple iterations, the statements about hard work and continuous effort were likely connected to the girls’ engagement in the STEM Princess figured world. This was also the likely source of all children using females as their examples to describe someone who was good at STEM.

Since the STEM Princess Ball was a female-centered experience, it made sense participants would describe a female as someone who is good at STEM. Children described someone who was good at STEM using examples from the STEM Princess Ball. Carrie, who wanted to be an astronaut prior to the event, was thrilled to meet an aerospace engineering student who hoped to work at NASA. Carrie realized “astronauts are good at STEM” because they have to do a great deal of mathematics and also understand how to fix their rocket if something goes wrong (Carrie Interview 2, October 6, 2018). This was a new connection Carrie made between STEM and being an astronaut, her career of choice. Similarly, three of the girls described me as someone who was good at STEM. Reagan declared, “Ashley is good at STEM because she is good at science,” (Reagan Interview 2, October 6, 2018) and Harper pointed out, “she is in charge of the STEM Princess and knows all of these other STEM people” (Harper Interview 2, October 6, 2018). The new focus on female examples for people who are good at STEM made me
wonder if these children would also pick predominantly females when presented with both males and females.

The selections of participants on the PASPT continued to favor females. There was an increase in how many females were selected after the STEM Princess Ball. The girls were more likely to select images of females, selecting images of females at a rate of 21 to 7 over images of males. This indicated participants were more likely to conceive of the STEM community as female after attending the STEM Princess Ball, a female-dominated STEM figured world. However, the most important indicators of being a part of the STEM community continued to focus on context: clothing, tools, and setting.

Like their drawings, girls continued to identify STEM people as those with stereotypic STEM clothing such as a lab coat and safety goggles. However, there was much greater emphasis on the surroundings of the individual. Girls searched for test tubes, flasks, animals, and rockets. Comparing images with a STEM background (see Figure 16-a) to an image with a neutral background (see Figure 16-b), children selected images with a STEM context at an average rate of 20 to 8. This was similar to their first selections from the PASPT. However, the girls selected more individuals with a neutral context than previously.
Girls said they previously guessed when two neutral images (see Figures 21 and 22) were presented against each other. After the STEM Princess Ball, their conception of who works in STEM broadened to include individuals outside of a lab and without stereotypic clothing. Taking the PASPT after the STEM Princess Ball, the girls, Eden and Reagan in particular, rationalized some of the neutral images as science teachers, engineers, and people who work with numbers further indicating engaging in the STEM Princess figured world during the Ball influenced their conceptions of the STEM community.
Figure 23. Harper’s drawing #1 of a STEM person.

Figure 24. Harper’s drawing #2 of a STEM person.

Figure 25. Harper’s drawing #3 of a STEM person.
Girls in the STEM Princess case drew one final image of someone in STEM during their last interview. All but one girl in the STEMP case drew an image of a female STEM person doing STEM activities. Many of the drawings highlighted how their conceptions of the STEM community changed over time. Harper’s drawings were a prime example. Harper’s initial (see Figure 23), STEM Princess Ball (see Figure 24), and final drawings (see Figure 25) emphasized the evolution of her conceptions. While her first two drawings have a change in activities, they continue to focus on many of the stereotypic images of STEM: science tools, manufacturing, fixing, etc. The elements of the drawings were not cohesive but an amalgamation of stereotypes. Conversely, Harper’s final drawing was unified: a scientist wearing a lab coat and safety goggles in a lab working with chemicals. It matched Harper’s explanation of STEM professionals that “make things like potions and stuff” (Harper Interview 6, January 17, 2019). Her conceptions of STEM and the STEM community were aligning to create a narrative where she fit and could identify with the community as a whole.

Hannah’s (see Figure 26) and Carrie’s (see Figure 27) final drawings were of women with something they created. Their drawings indicated their engagement in the STEM Princess figured world influenced their conceptions of what people in the STEM community do and look like. The STEM community drawings were not cartoonish or stereotypic. There was a notable lack of stereotypically STEM imagery in the drawings. Instead, the figures looked like average, every day people who create and invent. Their figures were wearing casual clothing and presenting a new invention that “helped make life easier” (Carrie Interview 7, February 6, 2019). Neither of their figures were wearing
stereotypical clothing such as a lab coat and safety goggles nor did the people have unrelated flasks and test tubes. Instead, the figures were using a wrench and building materials related to the construction they were doing.

Figure 26. Hannah’s drawing #3 of a STEM person.

Figure 27. Carrie’s drawing #3 of a STEM person.
Reagan and Eden took their conceptions of STEM people being typical people by drawing individuals they knew in settings unrelated to STEM. Reagan drew a photo of a football player (see Figure 28) that she said was her uncle, also the only male drawing.

My uncle was a football player… I think a quarterback… he does math for football ‘cause probably the coach will tell him what areas to go in and then he just visions everything like where it is supposed to go in his brain. (Reagan Interview 7, February 4, 2019)

Confused, I brought this up with Reagan’s mom. Reagan stated her uncle was a backup quarterback in college and formerly used geometry and statistics to create plays for the coaching staff. Although he was not in a lab or working with tools, Reagan was able to abstract her conceptions of STEM and apply them to her uncle as a part of the STEM community. This indicated a robust understanding of how STEM can be useful beyond the stereotypic settings.

Figure 28. Reagan’s drawing #3 of a STEM person.
Eden (see Figure 29) had a similar drawing: someone she knew in a neutral setting. Eden drew me in the casual clothes I was wearing during our interview that day. I was a person in STEM “because you come to interview me every time” and I ask questions all about STEM and people in STEM. She knows I do STEM “because [she] went to the STEM Princess thingy” (Eden Interview 5, November 27, 2018). Eden also mentioned the drawing looked like the STEM Princess role model she saw who “was a doctor” that liked to “play sports as well such as softball and track” (Eden Interview 7, February 8, 2019). The connection to strangers that Eden felt were her role models showed the STEM Princess influenced her conceptions of the STEM community. Drawings of approachable people with normal clothing showed the girls conceived of the STEM community as people they knew and engaged with on a regular basis. Their drawings and descriptions from the girls in the STEMP case expressed a sense of familiarity with the STEM community.

*Figure 29. Eden’s drawing #3 of a STEM person.*
Girls’ selections on the Pick-a-STEM-Person Test painted a similar picture of their conceptions of the STEM community over time. Girls’ dependence on context, like their drawings and descriptions, continued to dominate their selections. After three STEM Princess activities, girls selected images of people in STEM context over the images in a neutral context at an average rate of 20.5 to 7.5. This extended to 21 to 6 in the final experience of picking STEM people. In other words, the stereotypes related to STEM clothing and context were a primary reason children identified someone as a part of the STEM community, even more so than when the study started. The changes were not dramatic, indicating there was little to no change in their selections from after the STEM Princess Ball to the end of this study. Nevertheless, the rationales for their choices provided insights into changes they were experiencing in how they conceived of the STEM community.

After three STEM Princess experiences, girls looked for people “in a lab and wearing a lab coat and safety goggles” (Eden Interview 5, November 27, 2018). Girls were primarily relying on clothing, tools, and backgrounds related to science and engineering because those were the disciplines that stood out to them in their conceptions of the STEM community. Rose said, “Whenever I see a scientist, I pick it because I know science is a part of STEM. She has a lab coat that I've seen before and she has some science stuff in the background” (Rose Interview 5, December 12, 2018). The stereotypical clothing related to science and STEM was the most commonly cited rationale for their choices.
The close connections between clothing and context continued into their final selections in the PASPT. However, the clothing and context participants used to rationalize who was a part of the STEM community expanded. Carrie picked a person who she believed was an engineer because, “He has a hard hat and I know people who have hard hats are construction workers. And construction workers have engineering and have to keep trying and trying” (Carrie Interview 7, February 6, 2019). The other participants also rationalized their selection of individuals without a STEM background using careers they were now familiar with because “[they thought] he goes to teach science” (Hannah Interview 7, February 8, 2019). Evident by their selections and reasoning, the girls were beginning to conceptualize how STEM could be used in a broad array of fields and professions.

Girls referenced role models in their rationales for many of their choices shaping their conceptions of the STEM community beyond stereotypic clothing and settings. This was most apparent with the Black male in a neutral setting (see Figure 30). He was wearing a suit with short hair which were similar to former President Barack Obama, who had recently left office. Hannah selected the Black male in a neutral setting several times remarking, “He looks good, and I think he did STEM. Maybe he was a president because he looks familiar” (Eden Interview 7, February 8, 2019). Similarly, Eden selected this image because it “looks like he's a police and it says US” (Eden Interview 7, February 8, 2019). Their comments reflected a sense that people in STEM have powerful or important positions.
Another dominant connection girls made was to role models from the STEM Princess videos and other people in their lives. One of the images was of a Black male doctor wearing a white lab coat with a stethoscope and medical chart (see Figure 31). The girls were able to connect his background to their conceptions of the STEM community. Hannah knew he was a person in STEM because “he's doing stuff in an office. He's holding stuff because he's a doctor. I can tell by the thing around his neck [stethoscope]” (Hannah Interview 4, November 12, 2018). Similarly, Rose thought he was a nurse because her “mom was a nurse, and she's the closest relative in STEM” (Rose Interview 4, November 13, 2018).

Girls also made connections to the role models from their STEM Princess experiences. When presented with two females in STEM (see Figures 32 and 33), Rose debated on her choice.

Both are scientists. I picked this one (White female in STEM) because I pick the other one all the time. I've seen her (a Black female in STEM context) in the
videos, but I also know this one is a scientist. (Rose Interview 5, December 12, 2018)

Her reflections were after watching videos in her STEM Princess activities that featured a Black female mathematics professor and a White female physician assistant. Similarly, Reagan needed to choose between two people in STEM contexts and debated who to select because she had watched videos with role models from both STEM fields. “She has a lab coat and lots of science stuff behind her… They both do science, but in a different area. He's a doctor or nurse. They are both people in STEM, but I picked her” (Reagan Interview 5, November 26, 2018). Their conceptions of the STEM community were clearly shaped by those around them including the media from the STEM Princess figured world.

In their final experience selecting images from the PASPT, their rationales were similar to their previous PASPT selections. Girls continued to look for STEM clothing and context as well as individuals who were similar to their role models from media
sources, and figured worlds including home, school, and the STEM Princess. Choices where images of role models were compared to stereotypical images were particularly challenging for girls. For example, Carrie was presented with the Black male in a STEM context (see Figure 31 above) and a White female in a lab setting who looked vaguely like the physician assistant from a STEM Princess video. Carrie rationalized, “These are both doctors. Hard! It looks like she has STEM stuff, and she even has a rocket ship calendar” (Carrie Interview 6, January 23, 2019). So, Carrie picked the girl.

The girls’ preference toward females grew between the initial and second interviews indicating the female-centered STEM Princess figured world influenced their conceptions of the STEM community. At the midway point in the study, girls in the STEM case selected images of females over males at an average rate of 17 to 11. This was a decrease from their selections after the STEM Princess Ball. This more balanced proportion of female to male selections remained constant at 17 to 11 at the end of the study. It is significant to note the preference toward females remained dominant in the data, indicating their conceptions of the STEM community leaned toward feminine.

**Sense of Belonging**

Children were shown two different groups of 17 images of objects and locations related to STEM during our initial interviews. They were asked to identify which objects were for boys, girls, or both. Similar to their rationales about their drawings and the photos of people, children determined which gender the objects and places were connected to through personal experiences and relationships. When children have
connections to objects and places that are also associated with STEM, they are more likely to have a sense of belonging to STEM.

The early association of STEM-related objects to boys sends a strong message that STEM is for boys and girls may not belong. Not one of the images in the photo sort was identified as only for girls. Conversely, the four images related to building and fixing were consistently identified as boy objects. On one hand, Hannah identified eight images as explicitly related to boys while Harper named four. On the other hand, Reagan and Carrie determined all objects were for both even though a few of them, such as construction and tools, caused Reagan and Carrie to pause before answering. When asked about their pauses, Reagan and Carrie said they were not sure because they only saw boys, dads and brothers specifically, engage with the objects and places, but they were told “all things are for boys and girls” (Reagan Interview 1, October 1, 2018). Their pauses may be interpreted as moments where they had to think through conflicting messages to determine which is truth. The majority of the images were identified as for both boys and girls “because everything can be for boys or girls no matter what” (Carrie Interview 1, October 4, 2018). The girls had “seen these before” and knew “boys can do [STEM] and girls can do it” (Reagan Interview 1, October 1, 2018).

Their willingness, or lack thereof, to engage in conversation and relationship building with STEM professionals were connected to an insecure sense of belonging. Coupled with the object photo sort, selections of STEM persons, and their drawings, girls provided a conflicting conception of who belongs in STEM, indicating they were not quite sure if they belonged or not. An environment with familiar objects and people who
look like you are significant influences on developing a sense of belonging. It shapes the willingness to engage in activities and relationship building. Girls in the STEMP case were initially unsure about their sense of belonging in STEM. They were wary about engaging in a conversation with a STEM professional “because [they] might be nervous if they ask a really, really, really hard [question]” (Reagan Interview 1, October 1, 2018).

Some of the girls stated they were nervous because they did not know if their parents would approve of them talking to a stranger who may or may not be safe. When assured the STEM professional would be a safe person, girls were more willing to ask questions to the person. For example, “[Harper] would say, ‘What things do you do?’” when she was not sure she wanted to talk to someone in STEM before knowing the person in STEM was safe (Harper Interview 1, October 2, 2018). Similarly, Carrie wanted ask questions in a safe space that were specific to their careers such as, “If I met a scientist I would like to talk about science. If I met an engineer they could talk about how to build a new thing” (Carrie Interview 1, October 4, 2018).

The other salient influence on children’s sense of belonging in STEM was role models. Access to role models like teachers and STEM-related activities were central to the sense of belonging in STEM for the STEMP case. Some children in the STEMP case interacted with a variety of role models in STEM while other children had little to no contact with individuals in STEM which led them into uncertainty about who belonged in STEM. One child said “[she didn’t] know anybody” and had “no idea” who had a job in STEM or what people in STEM looked like (Harper Interview 1, October 2, 2018).
The other children had multiple people they considered family and friends who they identified as people in STEM, leading them to feel more comfortable in a STEM environment. Children mentioned male and female role models from within and outside their families: parents, grandparents, aunts and uncles, family friends, and siblings as people that like and are good at STEM. Rose even boasted, “My mom AND dad do STEM!” (Rose Interview 1, October 2, 2018). The most common STEM role model children mentioned was a teacher. Children focused on how their teachers were good at mathematics, knowledgeable about science, and smart. In particular, children identified their teachers as STEM role models because the students “have math and science journals, and [my teacher] tells me [if I got all the answers right]” (Reagan Interview 1, October 1, 2018). Because teachers were leading the instruction of mathematics and science lessons, they were central figures in their interactions with STEM content and held up as role models. The regular interactions with their teachers were an avenue for girls to have a sense of belonging because they considered their teachers to be a part of the STEM community.

The children in the STEMP case completed the same photo sort before and immediately after the STEM Princess Ball. There were no notable changes in their selections. This was significant because the STEM Princess Ball was a female-centered STEM figured world. The lack of connection between STEM objects and places with girls indicated the participants did not have a notable change in their sense of belonging even after engaging in the STEM Princess figured world. Reagan, Rose, and Carrie said each image could be for boys or girls. Eden, Harper, and Hannah each had a handful of
images they identified as for boys. Again, none of the participants said any of the images were primarily for girls. Over 75% of the images, on average, were labeled as “both because anyone can do anything. It doesn’t matter if you’re a boy or girl. STEM is fun for everyone” (Reagan Interview 2, October 6, 2018). Carrie even mentioned the space shuttle would be both because her group leader was an aerospace engineering major who planned to work on the new space shuttle (Carrie Interview 2, October 6, 2018). This was particularly exciting for Carrie because she helped them design test tube rockets that went far. The girls were making connections between their experiences and interactions at the STEM Princess Ball and the images they were classifying. However, there was not an experience related to construction to create a counter narrative that both boys and girls belong in construction or spaces with tools.

Throughout the study, children in the STEMP case remained consistent in how they sorted the photos of objects and locations related to STEM. The association between the STEM-related objects and locations with males remained, indicating a sense that STEM was more for boys than girls. Associating a field with the opposing sex adversely influences a sense of belonging. The images that were identified as masculine were the same as those in their previous interviews: tools and construction-related items. These were also items that were not emphasized during the STEM Princess Ball. The event had more role models in lab coats than hard hats and more activities focused on engineering design instead of building. The one change from boy to both was an image of a science center. This was closely related to the environment at the STEM Princess Ball indicating
the experience could have been the source of the shift in how the girls associated STEM with males or females.

Although the girls’ sorting of images related to STEM did not have notable changes, there were important changes in the girls’ willingness and curiosity related to talking to group leaders and other persons at the STEM Princess Ball. The girls’ increase in comfort indicated engaging in the STEM Princess figured world provided an opportunity to develop a sense of belonging in the broader STEM community. Like the sorting of images, the girls directly connected their comfort with a role model from the STEM Princess Ball. Some of the girls had a notable shift and “would feel comfortable talking to someone [in STEM] if they were safe [but] wouldn't want to ask anything in particular … maybe just about their job” (Reagan Interview 2, October 6, 2018). This was a departure from the initial interviews when children were not sure if they would even be comfortable having a conversation with a STEM person. Some had more subtle shifts, saying they would be “kind of comfortable talking to someone in STEM, [but were] not sure what to ask” because they “[didn’t] know anyone with a STEM job” (Harper Interview 2, October 6, 2018).

After one opportunity to build a relationship with female STEM professionals, the girls were more comfortable and interested in talking to members of the STEM community, indicating a growing sense of belonging. All six children mentioned a group leader, station leader, or me during their second interview. The conversations girls had with women at the STEM Princess Ball had a powerful influence on their confidence to engage in conversation with people in STEM and, ultimately, their sense of belonging.
They used the STEM Princess role models to connect themselves to STEM. In one activity with Legos, Eden was working with her group leader to figure out how many Legos were at the table. She said she “would be comfortable talking to someone in STEM because they know lots of good things like 1000+89,” which was the problem they worked on with the Legos (Eden Interview 2, October 6, 2018). Eden was also comfortable and excited to talk to STEM professionals because she could “also talk to them about science.” Similar to Eden, Rose realized should could talk to STEM people because “[she loves] science,” so they could talk more about “chemicals… planets… animals… plants and stuff” (Rose Interview 2, October 6, 2018). These were all areas of STEM Rose had talked about with her group leader because the group leaders were trained to connect the child’s interest to STEM topics and career fields.

The sense of belonging girls in the STEMP case expressed continued to develop over the course of the study. The girls also started connecting the items and people in the PASPT photos to their personal experiences with STEM. “She wears a lab coat and has goggles and gloves on. She also has stuff I use in my science kit” (Reagan Interview 5, November 26, 2018). Rose noted, “They are both scientists… They have the pumpers I have been using (describing a pipette from the most recent STEM Princess activity)” (Rose Interview 5, December 12, 2018). In other words, the STEM Princess activities were reaffirming some of their connections to stereotypical items in STEM. However, the girls also related to the people in the images because the girls saw the people were using the same items participants were using in their STEM Princess experiences.
The girls completed both sets of photo sorts on multiple occasions, identifying a total of 32 images for boys, girls, or both. None of the 32 objects and places shown to the girls were consistently identified as feminine. Only an image of a bug kit (see Figure 34) and another that featured kitchen chemistry with a kitchen counter with science equipment on top (see Figure 35) were identified by more than one child as for girls. This indicated the participants were not connecting females, like them, to STEM. On average, the girls in the STEMP case identified 1.92 images as for boys and .46 as for girls. The highest number of items identified for boys was five while the highest for girls was four. Images featuring the building process and robots were regularly associated with boys because they “don’t see girl construction workers” (Harper Interview 6, January 17, 2019). “[Construction] looks tough and boys are tougher than girls” (Rose Interview 6, January 8, 2019). In other words, they were not seeing girls interact with STEM places and objects at the same rate as boys causing a gap in their sense of belonging. The objects and places identified by the girls related to their sense of belonging and connections between STEM and females like them.

Figure 34. Photo sort bug kit.  
Figure 35. Photo sort kitchen chemistry.
An average of 14.11 of the 16 objects in each set were identified for both boys or girls because “it doesn’t matter what type you are, you can do any job” (Carrie Interview 7, February 6, 2019), a similar sentiment shared by several girls. Their statements and selections were in contradiction to one another. There were four times as many items identified as “for boys” reflecting a sense that more males belong in the STEM community, yet the girls were stating both boys and girls can do anything, including STEM. The rift left me wondering who they believed belongs in STEM, including themselves.

The interactions of the girls in the STEMP case with role models over time were a more personal and powerful influence on their sense of belonging in STEM. The girls conveyed they belonged in STEM after witnessing multiple females in STEM careers and making connections to other parts of their lives. The connections girls were making between people they knew and interacted with were central to increasing their sense of belonging in the STEM community. Carrie, who lives on a hobby farm with her parents and brother, described herself as a person in STEM because she works with her dad on the farm and “[he] works with girls… they all do farming” (Carrie Interview 3, November 14, 2018). A connection she had not previously expressed. Carrie expanded on why farming was a part of STEM remembering a time “[she] rode on the picker” at her grandparents’ home that was controlled by a joystick and computer screen (Carrie Interview 5, December 6, 2018). She also connected farming with engineering because, like engineers, farmers “build stuff and not get frustrated and not just quit” (Carrie Interview 3, November 14, 2018). This was nearly a direct quote from the STEM
Princess at-home experience Carrie just completed where children were creating and testing multiple iterations of bubble blowers. Her connections between her past experiences and those with the STEM Princess were evident in her understanding of who belongs in the STEM community. Engaging with a variety of STEM role models and experiences in STEM provided children multiple entry points to building their sense of belonging. The new sense of belonging and capability the girls in the STEMP case expressed was the foundation of self-efficacy.

**Self-efficacy**

The self-efficacy of girls in the STEMP cases was shaped across the figured worlds they were engaged in. Children’s STEM self-efficacy was initially connected to their school success. When asked if they were good at STEM, the responses varied greatly. Some girls said “[they] don’t know” if they were good at STEM, but thought they were “kind of” good at STEM because, “I am good at math … kind of [and] science is my favorite … because you can do lots of things” in school (Harper Interview 1, October 2, 2018). Similarly, Carrie said, “I know a lot about space from science, and I know a bunch of math problems and subtraction” (Carrie Interview 1, October 4, 2018). Their success and “positive feedback at school” (Reagan Interview 1, October 1, 2018) were powerful builders of girls’ STEM self-efficacy.

One indicator of self-efficacy in STEM is interest and future plans in STEM-related careers. The careers girls mentioned they would be good at were the same as their salient role models. For example, Harper planned to be “a workout teacher ‘cause that’s what [her] mom was. When [she is] tired with it, [she will] quit and marry somebody like
a normal mom.” Other girls considered careers based on what they expressed they enjoyed or felt they were good at, such as Reagan who was considering being a science teacher or dancer “because I love science and like dancing” (Reagan Interview 1, October 1, 2018). Rose wanted to be “a vet… because I like animals and helping them” (Rose Interview 1, October 2, 2018). In other words, girls’ made connections to what they and others around them were doing which shaped their self-efficacy.

The girls’ STEM self-efficacy built by the school success did not extend into their future career plans. The girls “kind of like science and math” careers, but did not say they could be a STEM professional (Harper Interview 1, October 2, 2018). Including STEM as a field they felt successful in or enjoyed was not mentioned. Only when specifically asked did girls discuss being good at or interested in STEM careers. Eden, Harper, and Rose were generally not sure which careers they could be good at when they grew up. Each mentioned several possibilities followed by, “I don’t know” (Eden Interview 1, October 4, 2018). Harper’s mom noted this may be because “we don’t really talk to our girls about jobs and careers, I guess.”

The career interests of the STEMP case broadened after the STEM Princess Ball. Harper wanted “to be a teacher and maybe a doctor,” both fields she had not previously shown interest in (Harper Interview 2, October 6, 2018). Similarly, Eden, who was in the same group as Harper, decided she wanted to be a doctor after the STEM Princess Ball not knowing what careers she was interested in pursuing during our first interview (Eden Interview 2, October 6, 2018). This was significant because one of their group leaders was previously a pre-med major who decided to transfer into science education.
The group leaders, particularly one which had the majority of participants, discussed her career plans with the girls in her group and made connections for the participants. Reagan, also in the group with Eden and Harper, decided she “[wanted] to be a science teacher” (Reagan Interview 2, October 6, 2018). Hannah, was in the same group. Even though Hannah continued to “want to be a horse trainer or gymnast,” she drew a medical person in an ambulance with a sick patient for her draw-a-STEM-person test, making the association between STEM and the medical field through their group leader (Hannah Interview 2, October 6, 2019). Hannah explained medical people help others, which is something she wanted to do. The group leaders proved to be powerful in shaping the girls’ career interest and self-efficacy.

The girls’ interactions with their group leaders shaped their career interests and knowledge of what they may do in those roles. As a doctor, they knew they would “have a doctor coat on and that thing that listens to your heart” (Eden Interview 2, October 6, 2018) because this is what their leader was wearing. New connections between their experiences at the STEM Princess Ball, home, and the things they liked were significant in the careers they expressed they could succeed in.

Making connections at the STEM Princess Ball provided a boost in self-efficacy for the participants. Experiencing success and building relationships with STEM role models was building a positive association between self, STEM, and the STEM community. Eden expressed a strong sense of self-efficacy, noting “I am good at STEM. My mom and dad both say I am … I like to do STEM stuff and did good here too!” (Eden Interview 2, October 6, 2018). Increased confidence and self-efficacy was a shared
feeling among other participants, too. As mentioned earlier, Carrie’s group leader was an aerospace engineering major. When asked if she felt like she was good at STEM, Carrie rationalized she’s “good at STEM because I like math and science… I want to be an astronaut… and an astronaut is good at STEM” (Carrie Interview 2, October 6, 2018). Carrie realized the things she was good at in school and her career interests were related to STEM. Coupled with a powerful interaction with a STEM role model, Carrie expressed increased self-efficacy in STEM and a rejuvenated excitement about her career of choice.

Girls who did not start with career aspirations related to STEM showed the most dramatic changes, often relating what they liked about the STEM Princess Ball to what they experienced at home. Eden was newly interested in medicine because her “mom and dad both say [she is] good at helping people get better…” and Eden was having fun with her mom fixing stuff at the STEM Princess Ball. It made sense for her to be interested in careers related to medicine because “doctors get to help people.” The fact that they also “get money. It’s a really good job” which made the job even more appealing to Eden (Eden Interview 2, October 6, 2018).

Harper was the one exception to expressing an increase in self-efficacy after engaging the STEM Princess figured world. Like her initial interview, Harper continued to feel she was “sort of good at STEM [because] I am good at math, but not really science” (Harper Interview 2, October 6, 2018). This was a slight change from her original interview when she felt she was really good at science, meaning she showed
some regression in STEM self-efficacy after engaging in the STEM Princess figured world while the others in the STEMP case progressed in self-efficacy.

The girls exhibited consistent growth in their self-efficacy in STEM over the three months after the STEM Princess Ball. The most significant growth in STEM self-efficacy occurred when children engaged in STEM across multiple figured worlds. For example, Carrie said she was good at STEM “because I do a lot of stuff [at home and school]” (Carrie Interview 3, November 14, 2018). At the same time, she was doing the at-home STEM Princess experiences, “[her class] did an experiment about how animals and plants survive to help Spruce the Sea Turtle do what she needs to do to survive… back in the ocean” (Carrie Interview 3, November 14, 2018). Her school experiences reinforced her STEM Princess experiences and vice versa. Formal learning experiences like “[doing] math every single day at school” (Carrie Interview 7, February 6, 2019) were commonly mentioned as reasons why participants knew they were good at STEM. Participants had the greatest growth in STEM self-efficacy when coupled with their STEM Princess engagement. They expressed feeling “good at STEM because I’m doing the [STEM Princess] projects with my family” (Eden Interview 6, January 8, 2019) like “[making] a paper airplane in a different way than I normally do” or “making a Lego car, trying to make it go just by a balloon” (Eden Interview 5, November 27, 2018). The layering of participating in STEM in the figured worlds at school, home, and STEM Princess was a significant influence on self-efficacy development.

For some of the girls, their new connections to STEM and increased self-efficacy manifested as increased interest in STEM careers. For instance, Harper started the study
wanting to be a “workout teacher because [her] mom was a workout teacher” (Harper Interview 3, October 30, 2018). After engaging in the STEM Princess figured world over a period of three months, Harper realized she was like the people in the STEM Princess videos “because they like STEM and I like STEM” (Harper Interview 6, January 17, 2019). When the STEM Princess experiences were reaffirmed by other relationships and figured worlds, the self-efficacy grew even stronger. In her final interview, Harper was interested in

…being an art teacher or… an engineer. I got an interest in it because at school I learned that they could do really awesome stuff that I didn’t even know about like make [a STEM Princess kaleidoscope] or make other stuff that we don’t even have. (Harper Interview 7, February 3, 2019)

Harper had feelings of self-efficacy because she successfully completed an engineering activity through the STEM Princess and at school, developing a sense she could be good at engineering. These experiences and relationships allowed her to identify as a STEM person in ways she did not originally. The notable changes Hannah and Harper expressed about STEM careers and the STEM community are indications of a growing self-efficacy in STEM.

The more the girls knew about STEM and engaged in the STEM community, the more connected they were to STEM careers and assured they could be successful in those careers. Eden wanted to be “a doctor or vet or artist” after the STEM Princess Ball and one STEM Princess experience at home (Eden Interview 3, October 29, 2018). However, she “[didn’t] know why” or what those jobs did (Eden Interview 3, October 29, 2018).
Like the other participants, Eden expressed a generally high self-efficacy, but her connections to STEM careers were weak, causing uncertainty.

Participating in the STEM Princess figured world helped provide clarity for girls about why they would be good at STEM careers, resulting in sharing more details and information about their self-efficacy in STEM. After completing all of the STEM Princess activities, Eden wanted to be “a doctor because you just may feel good because you’re helping them” (Eden Interview 6, January 9, 2019). This was a reflection of the role model she watched in the STEM Princess videos which “help me learn and they teach other kids” (Eden Interview 6, January 9, 2019). The video featured a physician assistant who “played sports as well, such as softball and track” which humanized her to Eden (Eden Interview 7, February 8, 2019). Eden wanted to be a doctor “because I want to be a STEM person” like the role model (Eden Interview 6, January 9, 2019). Eden, like the other girls, expressed self-efficacious beliefs in STEM “because [she does] the STEM Princess” (Eden Interview 5, November 27, 2018). Eden’s experiences with the STEM Princess had self-efficacy “because I believe in myself” (Eden Interview 6, January 8, 2019).

A change in their self-efficacy was still present when girls remained interested in the same careers they started with. Rose always wanted to be a veterinarian or inventor of Paw Patrol toys. Reagan was similar in her consistency. She wanted to be a science teacher during the entire study because she “loves science and kids. [Being a science teacher] combines to the two”: children and her love of science (Reagan Interview 7, February 4, 2019). Their career choices were based on their interests, not necessarily a
particular experience or person with whom they had interacted. Starting with a greater interest in and more experiences with STEM resulted in less obvious changes in self-efficacy. They were more interested in engaging in STEM, talking with STEM people, and pursuing STEM careers. This is a significant evolution in self-efficacy over time.

Carrie’s self-efficacy, like the other girls, blossomed from the beginning to the end of the study. “I know science and I’m exploring space, because when I grow up, I’m going to become an astronaut to discover space” (Carrie Interview 7, February 6, 2019). Carrie did not just want to be an astronaut. She believed she would be successful at space exploration and expressed a powerful sense of self-efficacy. Carrie persisted in wanting to be an astronaut in all seven of her interviews. She wanted to “travel to different planets and go to space … in a rocket ship to go to the space station” (Carrie Interview 5, December 6, 2018). However, persistence in selecting an astronaut does not mean Carrie did not experience change in her STEM self-efficacy. In the beginning, her interest in being an astronaut was because “it sounds fun” (Carrie Interview 3, November 14, 2018) without any discussion of STEM. By her final interview, Carrie connected her career interest to STEM realizing “astronauts are scientists. That’s why they go to space, to discover and learn about space” (Carrie Interview 7, February 6, 2019). She was excited to ask astronauts questions and engage in conversation, asking “Have you been to the space station? Or have you been to the moon?” (Carrie Interview 7, February 6, 2019) because she had inserted herself into the STEM community as a future astronaut.

Connecting their own interactions and success translated into increased self-efficacy in STEM for participants.
Some remained steadfast in their initial career choices that were unrelated to STEM. Even though all of the girls “thought [STEM jobs] were cool and interesting,” (Hannah Interview 7, February 8, 2019) indicating a potential increase in self-efficacy, their career goals remained focused on their interests and passions outside of STEM. Hannah wanted to be a gymnast or horse trainer during the entire study (Hannah Interview 5, December 3, 2018 and Interview 7, February 8, 2019). Although Hannah “[liked] doing crafts and stuff that engineers do,” she did not “want to do any jobs for it. I just want to do parts of stuff at my house” (Hannah Interview 7, February 8, 2019). However, Hannah’s increase in self-efficacy is based on the misconception that engineers do crafts, leaving me unsure if Hannah did indeed have an increase in self-efficacy specific to STEM.

The confusion around some unfamiliar careers was also clarified by the end of the study. Participants had a deeper and more accurate understanding of the careers connected to important role models or presented as a part of the STEM Princess experience, allowing them to build confidence and a greater sense of self-efficacy. The careers that were reinforced across figured worlds were those with which the participants expressed a greater feeling of competence and excitement. For instance, Hannah decided to consider becoming “a nurse” by the end of the study “because that’s what [her] grandma and aunt do” (Hannah Interview 7, February 8, 2019). She was excited to help people by making them not sick anymore by giving them medicine, which is what the physician assistant said in the STEM Princess at-home experience. This was a dramatic
change in for Hannah “that was a new one. She’s never mentioned wanting to be a nurse” (Hannah’s Mom Interview 7, February 8, 2019).

The increase in self-efficacy was evidence when participants decided to “keep trying and not give up… experimenting with things that you have never done before” (Hannah Interview 6, January, 6, 2019). Improved self-efficacy meant they were more willing to “experiment with things and really do it right” (Hannah Interview 7, February 8, 2019) or “put [stuff] together and end up with something amazing” (Harper Interview 7, February 3, 2019). Instead of concerns about not knowing, girls were excited to try and expressed confidence in their ability to eventually succeed in all STEM activities because “it’s real fun to do… I like that” (Hannah Interview 7, February 8, 2019). Significantly, the increased confidence and identification with STEM careers parallels the broader increase in self-efficacy expressed by the girls over the course of the study.

**Interest**

Girls initially had varying interests in STEM. When asked what they liked to do and play with, girls did not mention STEM. There were some predominant interests including: Barbies and dolls, playing with friends, and a variety of sports. Other stereotypically feminine activities, such as painting fingernails and crafting were also mentioned. Participants enjoyed using technology by watching YouTube, playing iPad games, and watching television shows. However, none of the participants considered this being interested in STEM because they were not building or creating on these devices. Instead, they liked “to change my background and color and stuff” on their iPads. The one reoccurring STEM interest girls had was building with Legos.
Girls said they liked STEM, but only when I specifically prompted about an interest in STEM. However, there was not an organic discussion of STEM in their interests indicating it was not at the top of their lists. Carrie enjoyed “learning new numbers with math and… learning a lot with science” (Carrie Interview 1, October 4, 2018). Likewise, Reagan “[liked] doing science and playing on technology and doing technology and [she liked] doing math” (Reagan Interview 1, October 1, 2018). Their references to school subjects indicated their interest in STEM was largely based on their formal learning experiences at school. None of them mentioned any informal learning experiences or engaging in STEM at home.

I specifically asked participants about their upcoming attendance at STEM Princess Ball to better understand why they were interested in attending. All of them were excited for the event, but not necessarily for the STEM component. Rose “[could] not wait for all of the experiments” (Rose Interview 1, October 2, 2018) while Harper was “excited to see Rapunzel” (Harper Interview 1, October 2, 2018) and Hannah wanted “to meet Elsa and Anna and all the princesses” (Hannah Interview 1, October 3, 2018). They were unsure what else they would be doing at the event and did not express excitement about experiments or building, with the exception of Rose’s comment featured above, indicating the girls were attending because of their interests in princesses not interests in STEM.

Many of the girls’ underlying STEM interests were brought to the forefront after the STEM Princess Ball. Eden said she liked to play with her friends, adding they enjoyed STEM activities “like math games and being outside” (Eden Interview 2,
October 6, 2018). Similarly, Rose shared how her love of the cartoon Paw Patrol and animals translated into STEM interests. She connected these interests to veterinary medicine or inventing and building new Paw Patrol toys as a potential career interest after building toys at the STEM Princess Ball (Rose Interview 2, October 6, 2018). While their existing interests in STEM-related items remained, the girls did not express new interests in STEM.

Similarly, Rose shared how her love of the cartoon Paw Patrol and animals translated into STEM interests. She connected these interests to veterinary medicine or inventing and building new Paw Patrol toys as a potential career interest after building toys at the STEM Princess Ball (Rose Interview 2, October 6, 2018). While their existing interests in STEM-related items remained, the girls did not express new interests in STEM.

Shortly after the STEM Princess Ball the girls did not express any emotions or personal feelings related to STEM similar to their joyful responses after the STEM Princess Ball. Each child mentioned the STEM Princess activities were “really fun to do… and [the princess activities] are really cool” (Hannah Interview 5, December 3, 2018) but this did not translate into how they conceived of STEM. Their focus was instead on the princess element instead of the STEM components of the at-home engagement in the STEM Princes figured world. Eden, for instance, mentioned she liked the pretty crafts and watching the princess videos but did not share the same excitement for the STEM content.

The STEMP case participants were connecting their interest and excitement to the “princess-y games,” but did not express the same interest or excitement over the STEM content. Like their reasons for attending the STEM Princess Ball, girls were more interested in the princesses than they were interested in STEM. For example, if they could be anyone or anything, many of them chose princesses like “Cinderella… because she’s my favorite princess” (Eden Interview 3, November 13, 2018) instead of the STEM professionals they had interacted with in the STEM Princess figured world. Recurring
and consistent interaction with STEM through the STEM Princess at-home experiences did influence them beyond their interest in princesses into their interests in STEM. Harper and Eden expressed interest in doing STEM by the end of the study and integrated it into their futures. Harper remarked she was “pretty sure [STEM]… like potions… and engineering” were in her future (Harper Interview 6, January 17, 2019). Harper “got an interest in it because at school I learned that they could do really awesome stuff that I didn’t even know about, like make [a STEM Princess kaleidoscope] or make other stuff that we don’t even have” (Harper Interview 7, February 3, 2019). Her experiences with the STEM Princess coupled with what she engaged in at school helped her understand she loves “to figure out how to do things and stuff like that” (Harper Interview 7, February 3, 2019).

Engaging in STEM activities in the STEM Princess figured world increased the girls’ interest in STEM. For instance, Eden thought “STEM is a fun activity, like whatever is in this packet (STEM Princess experience)” making her want to do more of them (Eden Interview 5, November 27, 2018). She was interested in doing more STEM activities “because I get to learn… and I liked how [the bracelet I made] glowed up in the dark and it changed colors in the light” (Eden Interview 4, November 13, 2018). Hannah was always thrilled to get her STEM Princess experiences because “they’re all just awesome… I love them!” (Hannah Interview 5, November 28, 2019).

The interactive design of the at-home STEM Princess activities left the girls hungry for more in-depth, child-centered experiences where they were able to create and interact with the STEM community. The STEM Princess experiences were “very cool
and I never knew about those experiments. I only get experiments in boxes for Christmas and stuff” (Reagan Interview 6, January 13, 2019). While Reagan was still interested in STEM, she wanted more of the STEM Princess experiences not the store-bought kits. Like the other participants in the STEM Princess case, Reagan pleaded for another kit because “I don’t want it to be the last one” (Reagan Interview 6, January 13, 2019).

STEMP participants’ interest in STEM was also dominant in what they wanted for gifts. The gift lists of the STEMP case transformed from dolls, Barbies, and “squishys” to STEM kits, computers, and Legos. For instance, Carrie, who was interested in space prior to the study, had a space-themed birthday party and requested almost exclusively STEM-related gifts such as Legos, a fort construction kit, a book on famous women in STEM, and several books about space (Carrie Interview 7, February 6, 2019). She even started learning how to code because she liked reading about Ava Lovelace and Grace Hopper in *Women in Science: 50 Fearless Pioneers Who Changed the World* by Rose Ignotofsky (Carrie Interview 7, February 6, 2019). This shift in their gift lists indicated girls were acting on their interests and requesting toys, games, and experiences that would permit them to continue engaging in STEM.

**Conclusion**

The girls were connecting the role models and experiences within the STEM Princess figured world with their personal interests, STEM self-efficacy, and a new sense of belonging. While their initial engagement in the STEM Princess figured world created a shift in their conceptions of STEM and the STEM community, it was engaging in the
STEM Princess figured world over time that had the greatest influence their sense of belonging, self-efficacy, and interest.

The first experience with the STEM Princess figured world, the STEM Princess Ball, planted the seed that participants in the STEMP case belonged and could have interests in STEM just like the group leaders. They experienced the STEM Princess Ball with their group leader and did the same activities. That translated to an increase in their STEM self-efficacy and a sense of belonging as a member of the STEM community. The STEM Princess Ball shaped their conceptions of STEM and encouraged the girls to conceive of the STEM community as female, reinforcing STEM was a place where they belonged and a field in which they could be successful.

The engagement in the STEM Princess figured world over time was when the sense of belonging, self-efficacy, and interest in STEM blossomed in the participants. Growth and development in their STEM sense of belonging, self-efficacy, and interests continued as the girls used the at-home experiences to continue engaging in the STEM Princess figured world. The changes in participants’ self-efficacy, sense of belonging, and interest were steady and incremental.

Perhaps the most significant growth was engaging in STEM across figured worlds: STEM Princess AND other figured worlds such as school. The compounding influence of the multiple figured worlds was a powerful force for the girls’ STEM identity development creating new expressions of competence and relevance. The girls who were able to draw upon experiences at home, school, and the STEM Princess exhibited the most complex and dynamic STEM identities.
The Business as Usual Case

The Business as Usual (BAU) case included six participants ranging in age from six to eight years in first and second grades. All participants were White females from the same geographic area with similar family dynamics. All parents had post-secondary education and considered themselves upper middle class. The similarities of the children in this case to the those in the STEMP case were part of what bound this case study. The case study as a whole was bound by participant demographics and time. The cases were bound by participation, or lack thereof, in the STEM Princess figured world.

The children in the BAU case started this study with a range in the frequency and types of STEM experiences they reported. Parents reported their daughters attended STEM events at their local libraries and engaged in STEM-related activities at home between one and seven times per month. Some of these activities included visiting a science center and/or zoo, having a science kit at home, and building with Legos. Prior to the beginning of the study, the BAU children engaged in STEM an average of three to four times per month across a variety of settings including home and school. This did not include instruction of mathematics and science. However, parents reported their children’s schools had STEM integrated into their curriculum. The engagement in STEM for the girls in the BAU case remained relatively constant over the duration of the study according to the parents.

I met with each child in the BAU case prior to the STEM Princess Ball. Because we were unfamiliar with each other and parents did not have an event to connect our time together, our first interview was a bit awkward and required a significant amount of time
to connect and get to know each other. I made sure to let each child see the iPads, cameras, and papers I brought with me. Each had questions about why I wanted to talk to them and what kind of things we would talk about. Our interactions over time helped ease their concerns and replaced them with ease and comfort.

**Conceptions of STEM and the STEM Community**

Children’s STEM experiences were associated with their conceptions of STEM and the STEM community. More specifically, children related STEM to the people, places, and objects with which they interacted. These interactions were the foundation for the conceptions they held.

Conceptions of STEM. Girls were hesitant to engage, at first, even when asking about what they thought STEM looked like or how it was defined. Ingrid, Penny, Bailey, and Emily neither knew what STEM was nor were they willing to guess. Remi also was not sure, but she guessed it was “the stem of a tree?” (Remi Interview 1, November 1, 2018). Ginny, who had a weekly STEM activity in her classroom thought “it was math stuff” (Ginny Interview 1, October 1, 2018).

Like the STEMP case, I described STEM by explaining it was an acronym for science, technology, engineering, and mathematics and a discipline that involved problem solving and critical thinking. Penny was unsure what engineering was and needed some additional information before saying “[she] got it” (Penny Interview 1, October 3, 2018). Each of the girls indicated they understood what STEM meant by nodding their heads or responding with a summary of what I just said. However, there was no indication they really understood or have conceptions about STEM. Their lack of elaboration and
willingness to share may have been due to their reservations about talking to me and engaging in the interview, yet it may have also been due to a lack of conceptions of what STEM actually was.

Over a week’s time, the girls’ conceptions of STEM changed slightly as they had a better grasp on what STEM was. Bailey’s mother talked to her about what STEM was after her initial interview because it sparked a few questions from Bailey (Bailey’s Mom Interview 1, October 9, 2018). This may be true for other children and the source of their developing conceptions. Even though the BAU case did not attend an event, like the STEM Princess Ball, they had a new experience related to STEM by interviewing with me.

During the second interview, using words that make up STEM, science, technology, engineering, and mathematics, was most common (Bailey Interview 2, October 9, 2018). The girls were better able to express their conceptions of STEM when encouraged to stray away from the acronym. Their conceptions of STEM centered on fixing and “[making] stuff” (Penny Interview 2, October 10, 2018). “It is science, math, technology, and engineering… like making new things that you’re trying to do and you make it” (Remi Interview 2, November 12, 2018). They realized using “science, mathematics, engineering, and math” people can “fix stuff for technology… building stuff or try something new” (Bailey Interview 2, October 9, 2018). Although Emily agreed STEM was about creating, she focused on the creation of art, not inventing or building for the remainder of her interview.
For the other girls, it was a challenge to recall even the acronym, an indication little attention was paid to STEM since our initial interviews. For example, Ginny remembered, “It’s scientists,” but could not remember the rest because “I only know that it’s science” (Ginny Interview 2, October 10, 2018). Engineering was the hardest to remember for children. The girls often remembered their school subjects of “Science, math… technology…” and then added “I almost forgot” when getting to engineering (Penny Interview 2, October 10, 2018). This made the girls less confident in their understanding of what STEM looked like. Ingrid stated she did not know what STEM was (Ingrid Interview 2, November 27, 2018). She could picture what it looked like to do science, technology, and mathematics. However, Ingrid did not know what engineering was which made her unsure about her conceptions of STEM.

In a confusing interaction, Emily described her conceptions of STEM through a detailed story of “one kid [who] had a spill on a library book. So, somebody that probably doesn’t keep the books good… he would be a little bit [good at STEM]” (Emily Interview 1, October 1, 2018). When pressed to explain why spilling on books was related to STEM, Emily said he was good at STEM, “but he just needs to keep books safer like not getting food on there” (Emily Interview 1, October 1, 2018). I realized she was describing a child in her class that she believed was good at STEM by telling stories about him. However, Emily was not able to tell me why she thought he was good at STEM or why this example highlighted her conceptions of STEM. Emily’s conceptions of STEM vacillated and portrayed many misconceptions of STEM, such as STEM as art.
Emily conceived of STEM as structured and requiring a process, which was similar to the other girls in the BAU case. However, Emily’s focus on artistic endeavors made Emily’s conception an outlier. STEM involved people who “color. They write. They color with markers and colored pencils… The art teacher, he only tells us what to do… Step one, step two, and step three.” Emilys also drew an art teacher when asked to draw someone in STEM, which developed a clear understanding of Emily’s conceptions of STEM (see Figure 36). Based on how I defined STEM in this study, Emily had a misconception that STEM was the same thing as creating, as in art.

Figure 36. Emily’s drawing #2 of a STEM person.
A range of conceptions about STEM continued throughout the rest of the study. Some girls in the BAU case, including Ingrid, Emily, and Remi, held conceptions of STEM that were limited to the definition in the prompt I provided during the interviews. Around two weeks into the study, these girls continued to struggle with expressing any conceptions of STEM they held or even how they defined STEM beyond my prompt. Ingrid didn’t know what STEM stood for, but after I provided the STEM definition, she conceptualized STEM as “just activities and experiments” (Ingrid Interview 3, January 8, 2019). Similarly, Emily and Remi struggled to conceptualize what STEM was guessing “art, music, technology, and… people are doing stuff” (Emily Interview 3, October 23, 2018) or referring back to their school experiences where STEM was “technology and we do math” (Remi Interview 3, January 16, 2019). These girls were able to provide more details about their conceptions of STEM as time went on. However, their conceptions of STEM continued to be closely aligned to the prompt I provided during the interviews. When asked to elaborate on what it looked like to do STEM, their answers were also a part of the prompt noting “it’s engineering, math, technology, and… [they] fix stuff, maybe, or solve problems” (Ingrid Interview 5, February 12, 2019). It was “science stuff and math… maybe build a bench in the sunroom when it’s warmer” (Ingrid Interview 4, February 5, 2019) or “[make] a potion” (Ingrid Interview 7, March 22, 2019).

Few changes in the conceptions of STEM held by Ingrid, Emily, and Remi occurred over the course of the study. Emily continually referenced her father who mentioned his job used STEM. This meant STEM “is when you help people” like when her dad “zapped my nose” (Emerysn Interview 7, February 7, 2019). However, this group
in the BAU case did not have many role models in STEM to reference. This led to Emily, Ingrid, and Remi without STEM conceptions outside of those related to school. Projects such as “[building] a city [out of cardboard] with my classmates” (Ingrid Interview 7, March 22, 2019) were central to how the BAU case conceived of STEM.

Their lack of connections to STEM led to a conception that STEM was challenging and difficult.

[STEM is] a thing where you work really hard on to do STEM. STEM is really hard because it is mostly all teachers… Then engineering is really hard because you have to work. You’ll get all sweaty and stuff like that… and probably so hard that you get tired of it, and you don’t want to do anymore. (Remi Interview 6, March 9, 2019)

Unlike Emily and Ingrid, whose conceptions were the same through the end of the study, Remi expressed an abrupt and dramatic shift in how she conceived of STEM during her final interview. Suddenly, STEM was “a job that people might love to do. It’s math, engineering, science, and… technology… Like people that help us and create new stuff” (Remi Interview 7, March 24, 2019). Remi did not indicate she was doing anything new at school related to STEM. However, her mother admitted they had a change in child care during the last few weeks.

[Grandma] has been watching the kids. I told her about this [study], and she’s been working with the kids on STEM stuff. She’s a former principal, so she was so excited when I told her Remi was working with you on STEM stuff. (Remi’s Mom Interview 7, March 24, 2019)
Remi’s change in her figured world at home strongly influenced her conceptions of STEM and shaped STEM into an important and approachable subject. Without any opportunities to engage in STEM activities or conversations, Emily and Ingrid did not express any major developments in the conceptions they held about STEM.

The other girls in the BAU case started to develop a more robust conception of stem based on their interactions during our interviews and what was happening in their home and school figured worlds. Bailey, Ginny, and Penny, like Remi, engaged in experiences that shaped their conceptions of STEM. These girls built rich conceptions of STEM over the course of the study. Their shifts centered around engaging in STEM at school. Shortly after the STEM Princess Ball occurred for the STEMP case, Bailey, Ginny, and Penny held few conceptions of STEM and, like the other BAU girls discussed above, largely repeated my prompt with some errors like “math, science, technology and…” “…mathematics…” (Bailey Interview 3, October 25, 2018) or “…social studies” (Penny Interview 3, October 24, 2018). The girls understood “teachers do math” (Ginny Interview 3, November 5, 2018), but they did not know what else people in STEM careers did.

The fourth round of interviews occurred in late October and early November around the same time the second quarter of school began. Bailey, Ginny, and Penny were all in classrooms where the teachers started STEM units during this time, which had a dramatic effect on the conceptions they held about STEM. In their STEM lessons, they were working on solutions for real world scenarios like
two girls that want to have shade in the park but we have to have a bench that has to be sunny and one that has to be shady. So we made some papers on how to do it. We made shadows… We also make ramps… and a return sweep (Bailey Interview 6, January 15, 2019).

The exposure to STEM at school transferred to their conceptions of STEM more broadly. Instead of referencing the siloed subjects, STEM experiences at school helped children conceptualize how STEM could be used and implemented in their projects.

Bailey, Ginny, and Penny were able to seamlessly repeat the acronym “science, engineering, technology, and math” (Ginny Interview 7, February 5, 2019) by the final interview, as well as elaborate on what it looked like to do STEM including, “building… fixing something or making something” (Bailey Interview 7, February 4, 2019). More experiences with STEM enriched their conceptions of STEM. Penny, who only had one STEM activity in school, did not abstract her conceptions of STEM like the other two, who experienced multiple STEM activities the rest of the school year. Penny’s examples of STEM included “building stuff, doing [experiments], doing math, and they are doing technology” (Penny Interview 7, February 6, 2019). She essentially added a verb before each of the words in the acronym STEM. Although there were differences in the conceptions of STEM within the BAU case, their conceptions of the STEM community were closely aligned.

Conceptions of the STEM Community. To better understand their conceptions of the STEM community, children in the BAU case drew a picture of a STEM person. All of the girls drew female characters which is a departure from previous studies (Chambers,
The girls in the BAU case drew one of two things: a person they knew or a media depiction of a STEM person. In other words, girls drew people in STEM they previously engaged with either through observation or with whom they had a relationship. Specifically, the children drew people who were a part of the figured worlds they had access to and were engaged in prior to this study.

The girls’ drawings and descriptions indicated the girls held conceptions about the STEM community. Remi and Emily drew images related to their schools. Their images focused on familiar environments and stereotypical imagery including science tools, computers, and indications they believed STEM was difficult, such as needing help or adult assistance. The images reflected a sense of STEM being challenging. Remi (see Figure 37) drew “a girl that’s playing her game and she got stuck on something, so the technology person, teacher, she came to help. She’s coming to help her fix her computer” (Remi Interview 1, November 1, 2018). Similarly, Emily’s image (see Figure 38) was also in a technology classroom where she is “playing this bubble game on the computer” (Emily Interview 1, October 1, 2019). Both girls also drew a female in their school with whom they related to one of the STEM subjects because that is who they were familiar with in their lives. They used their role models to represent people they thought were a part of the STEM community.
Figure 37. Remi’s drawing #1 of a STEM person.

Figure 38. Emily drawing #1 of a STEM person.
Ingrid and Penny also drew people they knew, but their drawings were of family members. Ingrid’s image (see Figure 39) depicted her mom who “works with math stuff” (Ingrid Interview 1, November 2, 2018). It has “a computer… pictures of us… and a wall,” but her mother was not present in Ingrid’s drawing. Penny, on the other hand, only drew a person at first: her sister who “the only thing she makes is slime” (Penny Interview 1, October 3, 2018). I asked her to add in the details that showed her sister making slime (see Figure 40) as it was originally just the person. Although Ingrid and Penny stated they knew the person in their drawings was a part of the STEM community, neither child was able to describe why or what it looks like to do STEM. They both expressed “[STEM] is hard” and “you have to be careful” (Penny Interview 1, October 3, 2018) indicating the STEM community was an elite group.

![Figure 39. Ingrid’s drawing #1 of a STEM person.](image)
In contrast to the other girls in the BAU case, Bailey and Ginny drew images of people who they had seen in media sources. Unlike the other images from the BAU case, these images included more stereotypes associated with STEM, including tools and masculine appearance with pants and boxy figures that went against their stated conceptions of females even though the figures were labeled as girls. Bailey drew a female “engineer that makes boxes” (see Figure 41) (Bailey Interview 1, October 1, 2018). It was a person “on a show she saw one time on YouTube. She fills the boxes too” (Bailey Interview 1, October 1, 2018). Bailey decided the person in her drawing was a STEM person because “engineers build stuff” (Bailey Interview 1, October 1, 2018). Bailey did not provide any additional detail about what the person in her drawing did or how Bailey knew engineers build and fill cardboard boxes. Bailey held conceptions of STEM related to building but could not explain why filling cardboard boxes was related to engineering or STEM.
Ginny drew a cartoon-like figure (see Figure 42) she named “Emily” (Ginny Interview 1, October 1, 2018). She had many of the same elements present from the original “Draw-a-Scientist Test” including a flask and safety glasses. Ginny’s drawing was “just a character” she made up not anyone in particular (Ginny Interview 1, October 1, 2018). However, Ginny’s mother helped me connect Ginny’s drawing to her favorite book series, *Ada Lace* by Emily Calandrelli (Ginny’s Mom Interview 1, October 1, 2018). The image depicted the main character from the book and was named after the author. Although Ginny, like Bailey, created drawings of people they did not personally know. The girls formed conceptions of the STEM community based on people they were familiar with through the media they were consuming.
The participants in the BAU case referenced their role models and past experiences with people in STEM to determine what people in STEM do in their careers. However, the girls struggled to describe what people in STEM do in their jobs. Ingrid, who mentioned her mother was the only person she knew who worked in STEM, but did not know what she or other STEM people do, resulting in a weak conception of the STEM community (Ingrid Interview 1, November 2, 2018). Penny provided the same response. She also “[didn’t] know what jobs they might have,” other than working on computers like her mother (Penny Interview 1, October 3, 2018).

Without a family member in STEM, Remi described the STEM community using her teachers because “they do science. They do technology sometimes on a certain day. They sometimes do engineering that I don’t really know that well. And they do math like everyday!” (Remi Interview 1, November 1, 2018). Remi, in an attempt to guess a career
outside of school just added “person” to the end of the words to guess “math person” and “engineering person.” In other words, the children grasped what STEM was in school, but did not hold conceptions about what people with STEM professions do in their jobs.

The selections on the PASPT were similar to their drawings with their choices more focused on the context and less on gender. Girls looked for context related to their conceptions of STEM such as clothing and tools. They made their selections by “[looking] at the background and” (Remi Interview 1, November 1, 2018) “some of them had bottles that I saw and some science stuff” (Bailey Interview 1, October 1, 2018). Girls also focused on the actual people in the images instead of emphasizing their background. They looked at “their face… and their outfit, so like I felt whether they would work in STEM. Engineering parts… and outfits of science” (Remi Interview 1, November 1, 2018). “They have white suits on and then they have a thing around… a stethoscope… since there was a doctor and science, I think” (Penny Interview 1, October 3, 2018). In other words, they were looking for many of the same personal items and objects referenced in previous draw-a-“something” tests (Chambers, 1983; Knight & Cunningham, 2004; Picker & Berry, 2000). In contrast to these studies, the BAU case did not have any notable differences in the selections related to sex, eluding to a gender-neutral conception of the STEM community.

The selections on the PASPT indicated girls in the BAU case continued to rely on context to determine who was in a STEM field. Children selected images with a people set in a STEM context at a rate of 19 to 9. This means the individuals with STEM-related background and clothing were selected more than twice as often compared to the images
of individuals without STEM-related objects and clothing. When context and clothing were missing on both individuals the girls “didn’t know which one to pick and just touched one” (Penny Interview 1, October 3, 2018). This aligned with their male versus female ratio. Girls selected an average of 13 males and 15 females. Girls’ selections emphasized what was in the picture instead of who was in the picture. Their initial conceptions of the STEM community were related to clothing, tools, and setting. Gender did not seem to matter. The dominance of females in their drawings was not present in their selections on their PASPT. In contrast to their drawings, their associations between the STEM community and STEM and sex were notable.

I interviewed the BAU children two weeks later following the same schedule as the STEMP case. While girls’ drawings had some changes in their conceptions of the STEM community, the differences between their images before and after the time period when the STEM Princess Ball occurred were slight. The drawings the girls from the BAU case created to depict a person in STEM featured many of the elements girls used to describe their conceptions of STEM. Bailey, Ingrid, Ginny, and Penny drew images that
were nearly identical to their first images. Bailey’s second drawing (see Figure 43) was a near copy of her first drawing (see Figure 44) featuring an “engineer” who built “a cardboard box” and “put stuff in it” (Bailey Interview 2, October 9, 2018). The only notable change from her first drawing to the second was her figure was a boy compared to a girl in her first drawing. Like Bailey, Ingrid drew a nearly identical image of her mother’s office (see Figure 45) but remembered to include an image of her mother in her office this time (see Figure 46). The similarities in the drawings of people in STEM suggest there were not changes to their conceptions of the STEM community.

Their drawings indicated little change in their conceptions of what it looks like to do STEM and how they conceived of the STEM community. Ginny’s drawings (see Figures 47 and 48) also appeared to depict the same person, but they were not the same according to Ginny’s description. Ginny’s drawing featured an important role model in her life. Ginny’s first image of a figurative scientist (see Figure 48) was transformed into her grandmother, Noni (see Figure 49), “that worked at the hospital” because “they do science and technology” (Ginny Interview 2, October 10, 2018). Using a role model
allowed Ginny to develop a more detailed drawing and description of someone in the STEM community and what it looked like to do STEM.

![Image of two drawings](image)

Figure 47. Ginny’s drawing #1 of a STEM person.

Figure 48. Ginny’s drawing #2 of a STEM person.

Like Bailey, Ingrid, and Ginny, Penny’s second drawing seemed to depict the same person with slight modifications. However, Penny provided details of her drawing that highlighted how her second drawing was actually different than her first. In other words, the drawings were substantively different in Penny’s mind even though the imagery of the drawing was the same or very similar. For example, Penny’s first and second drawings (see Figures 49 and 50) appeared to feature the same person; and table, with a new item on the table. However, according to Penny, her second drawing (see Figure 50) did not feature her sister making slime but Penny, herself, working on “a math tub that we have a board and then our math journal” (Penny Interview 2, October 10, 2018). The shift from drawing her sister to herself is an indication that Penny understood
her mathematics classes were related to STEM and a developing conception of what it looks like to do STEM.

Figure 49. Penny’s drawing #1 of a STEM person.  

Figure 50. Penny’s drawing #2 of a STEM person.

Remi, similar to Penny, chose to draw herself working on a math tub, “thinking about my math sheet, and I know this one and that, and then I counted…” because STEM is doing math in lots of different ways (Remi Interview 2, November 12, 2018). Like her first drawing, Remi (see Figure 51) continued to depict STEM in the school environment, but featured mathematics instead of technology. This indicated formal STEM learning is a strong force for shaping kids’ conceptions of STEM and who is a part of the STEM community.
Girls referenced their role models and family members when they described what it looked like to be a person in STEM. For example, Remi described how her “technology teacher” used her computer to help the students make books on the computer by “[doing] something and they make these different colors of things, and then they put them together and then they make something” (Remi Interview 2, November 12, 2018). Even though Remi understood her teacher was using STEM, she was not sure what her teacher was actually doing and how what she was doing worked. The disconnects in Remi’s conceptions of the STEM community emphasize the limitations she had in her conceptions.
The lack of knowledge about STEM careers and the STEM community created conceptions that were weak and unclear. This was consistent with Ingrid’s and Ginny’s descriptions of the jobs of people in STEM. Ginny continued describing how her grandmother was a STEM person because “she helps babies when they’re born. Noni fixed a heart the other day on a baby” (Ginny Interview 2, October 10, 2018). However, Ginny did not know what it meant to fix a heart. Similarly, Ingrid continued describing her mother who “works on math,” but did not know what her job entailed or even her job title (Ingrid Interview 2, November 27, 2018). The other girls provided descriptions of the STEM community using male role models including the only two male teachers in a school and their fathers.

The setting and surrounding objects were salient to girls’ conceptions of the STEM community in their drawings, as well as identifying which images showed people they thought were a part of the STEM community. The girls primarily selected images from the PASPT based on context. Girls looked for clothing, tools, and background objects that were stereotypically associated with STEM. People in STEM “had bottles and stuff [because] people in science use those kind of bottles” (Bailey Interview 2, October 9, 2018). Their selections were based on if “it was doctors and scientists,” (Penny Interview 2, October 10, 2018) indicating these were the most salient associations girls made to the STEM community. Girls selected images in the PASPT with STEM objects and settings at an average ratio of 18 to 10 when compared to images with a neutral setting. This means the BAU case strongly preferred stereotypical imagery and focused less on the person in the photo.
There was not any mention of other demographic factors the girls used to determine if a person in the PASPT photos was a part of the STEM community. More specifically, participants in the BAU case did not mention sex as a factor in their selections. When there was not any STEM clothing or context present, the girls “just picked the one I liked the most” (Bailey Interview 2, October 9, 2018). The girls gave preference to their own sex by selecting females over males at a ratio of 15 to 13. It is notable that participants preferred females, albeit by a small difference. A gender-neutral or female-dominant conception of STEM is a departure from previous research (Chambers, 1983; Knight & Cunningham, 2004; Picker & Berry, 2000).

The conceptions of the STEM community held by the BAU participants were relatively unchanged throughout the study, which was reflected in their drawings and selections on the PASPT. Their drawings consistently depended on stereotypes associated with STEM such as science tools, lab coats, and fixing. Just as their conceptions of STEM focused on familiar settings, so did their drawings of the STEM community. Emily (see Figures 52, 53, and 54) drew a variety of school classrooms: technology, art, and mathematics. She featured herself in each of the drawings doing activities she related to STEM: computer games (technology), art (creating), and a dice game (mathematics). However, Emily could not describe why these activities were STEM. Her conceptions of the STEM community were limited to her STEM experiences at school.
Like Emily, Ingrid consistently drew images of her mother because “her job is doing math and she works on a computer to do math” (Ingrid Interview 7, March 22, 2019). Her first image is of just her mother’s office (see Figure 55), the second is the office with her mother (see Figure 56), and the final image is just her mother (see Figure 57). Neither Ingrid nor Emily mentioned any STEM experiences or significant changes in their lives related to STEM. The consistency of their conceptions of the STEM
community depicted in their drawings were a reflection of how little outside influence
Ingrid and Emily had access to.

![Figures 55, 56, and 57 showing Ingrid's drawings of STEM persons.]

Exposure to STEM within the figured world of school did not have a significant
impact on the girls’ conceptions of the STEM community. Ginny, whose classroom
integrated STEM into their science block, had almost no change between her first (see
Figure 58) and final drawings (see Figure 59). The drawings both depict a female
“scientist” character holding a flask and wearing a white lab coat and safety glasses
(Ginny Interview 7, February 5, 2019). Ginny described how they used their science time
at school for STEM once per week. As a result, Ginny closely aligned STEM with scientists. Instead of broadening her conceptions of the STEM community, Ginny’s experiences at school reinforced some of the stereotypical items from science as elements salient to the STEM community. The outcome was a cartoonish version of the STEM community.

Bailey continued to rely on stereotypical imagery in her drawings using objects and clothing to provide cues her person was a part of the STEM community (see Figure 60). She depicted the STEM Barbie she received as a Christmas gift. Bailey retrieved the doll from her room and proceeded to draw the Barbie including the white lab coat, computer, and notebook she came with and commented that the STEM Barbie “likes working on her computer and reading” (Bailey Interview 7, February 4, 2019). These drawings indicated the conceptions of the STEM community Ginny and Bailey held were not significantly influenced by their school experiences in STEM.
Remi did have significant changes in her conceptions of the STEM community. Unlike Ginny and Bailey, Remi’s conceptions of the STEM community were shaped by experiences she had at home with her grandmother. This had a greater influence on her conceptions of the STEM community. Remi’s initial drawing was of a technology classroom (see Figure 61) and teacher that depicted STEM as difficult with the child needing help. In comparison, Remi’s final drawing (see Figure 62) featured “somebody engineering,” but the conception of engineering she held was “fixing someone’s car because they had one of their pipes under their car broke” (Remi Interview 7, March 24, 2019). The changes in her drawing schema showed her conceptions of the STEM
community were developing in concert with conceptions of STEM even if they were not completely accurate. Perhaps most importantly, Remi’s final drawing illustrated a person doing STEM not, asking for help, which was an encouraging change from her initial drawing that indicated being a part of the STEM community was challenging. Remi was the exception in her changes as the other girls did not show significant changes in their schema comparing drawings from the beginning and ending of the study, signifying a change in the conceptions she held of the STEM community.

![Figure 61. Remi’s drawing #1 of a STEM person.](image1.png)  
![Figure 62. Remi’s drawing #3 of a STEM person.](image2.png)

The selection of images on the PASPT aligned with the drawings from the BAU case. Like their drawings, the participants in the BAU case preferred females over males at a rate of 15 to 13. This was identical to the rate from the beginning of the study, showing no change in their conception of the STEM community. Further, there was little change in the rate of selecting images of people within a STEM context over a neutral context. Girls preferred the images with a STEM context at a rate of 19 to 9. However, there was an outlier in the final PASPT assessment that did not exist in previous sessions.
Emily’s selections were dramatically different than the other girls, making her selections outliers. Emily selected almost equal numbers of images with STEM backgrounds (13) and neutral backgrounds (15). When Emily was not included in the average, the group average rate shifted 1.5 from 19:9 to 20.5:7.5 in favor of STEM backgrounds. However, the data suggests Emily did not prefer images with STEM backgrounds. Instead, Emily preferred images of males over females regardless of background or context. Emily selected 17 images of males and only 11 images of females. This was nearly a perfect reversal compared to the other girls who preferred females at a rate of 16 to 12 over males. The average rates of male versus female images selected without Emily align with the beginning of the study. Emily, unlike the other girls, conceived of the STEM community as masculine. The BAU case, without Emily, conceived of the STEM community as slightly feminine and relied more on stereotypical imagery to determine who was a part of the STEM community.

Emily’s assumptions about the people in the images explained why she preferred males over females. When a male was in a neutral environment (see Figure 63), Emily decided “he looks like a teacher” or “police officer” (Emily Interview 6, January 7, 2019). Even when the male had a neutral background, but “he has a fancy shirt that looks like he’s a president or police officer,” (Emily Interview 5, November 30, 2018) that was enough for Emily to select the male over the female in a STEM context. When presented with a female in a chemistry lab with blue, red, and white solutions in the background (see Figure 64) compared to a male in a neutral context (see Figure 65), Emerysn rationalized “She’s just having water (blue solution) and ketchup (red solution) and ranch
(white solution). He’s a teacher” selecting the male (Emily Interview 6, January 7, 2019). By contrast, a female in neutral context “kind of looks like she stays home with kids.” This was a direct reflection of her parents. Emily’s father worked in a dermatological clinic while her mother was a homemaker and day care provider. Her selections mirrored the role models across her figured worlds which shaped her conceptions of the STEM community.

Figure 63. Black male in a neutral context.

Figure 64. Black female in a STEM context.

Figure 65. White male in a neutral context.
The rest of the girls in the BAU case made selections dominated by STEM context. The girls looked for images with “science tools and goggles on” (Penny Interview 6, January 7, 2019) or “a white lab coat” (Ginny Interview 6, January 23, 2019). Girls remarked when they saw a person “doing a potion” (Ingrid Interview 7, March 22, 2019) or “making some sort of liquid” (Bailey Interview 6, January 15, 2019), they knew that person worked in STEM. These indicators were all stereotypically associated with STEM careers and the same characteristics present in the DAST and DAET (Chambers, 1983; Knight & Cunningham, 2004).

The girls were in conflict about the medical profession and helping people. Some did not select the image of a doctor (see Figure 66) “because I know this one is a doctor and a doctor is not STEM” (Bailey Interview 6, January 15, 2019). In contrast, others thought “a doctor is part of science” and therefore a part of STEM (Ginny Interview 6, January 23, 2019). Doctors have “a lot of stuff and he has those glasses that makes him look like he does a lot of stuff. He looks like he helps people” (Emily Interview 6, January 7, 2019). The other girls did not think helping people was a characteristic of STEM. Remi thought one of the people was “helping people and STEM doesn’t help people” (Remi Interview 6, March 9, 2019). The conceptions about doctors and helping as a part of STEM suggests there may be some tensions about what STEM is and what it means to do STEM.
When the STEM context was not present, the girls in the BAU case selected more females than males, often connecting the images to role models. Ingrid, for example, regularly selected the White female (see Figure 67) despite being in a neutral environment because Ingrid “[thought] she just does mathematics and technology [like her mom]” (Ingrid Interview 7, March 22, 2019). The other girls used similar logic, deciding one image was “a teacher doing some sort of math” and another was “doing engineering because of the flag” (Ginny Interview 6, January 23, 2019).
The objects and clothing were central to how the participants were conceiving of what the STEM community looked like. The people girls described who was good at STEM and used many of the same characteristics as those who were selected in the PASPT or depicted in their drawings. Girls used stereotypical imagery related to STEM fields to make their choices. Ginny made her selections based on the context surrounding the person.

I saw the flask to use for science or the real thing. I also saw a lot of people’s lives behind them and I thought one of them had something, some kind of suit that felt like he was a police officer, a person who makes the buildings sometimes. I would think of that as engineering. (Ginny Interview 7, February 5, 2019)

Girls thought the STEM community may “fix stuff, maybe, or solve problems” (Ingrid Interview 5, February 12, 2019). “Sometimes they are building stuff and trying to fix things” (Bailey Interview 3, October 25, 2018). Overall, a STEM person “helps me solve problems and works on a laptop… [A STEM person] works and builds things… makes things and rebuilds things that are broken” (Bailey Interview 5, November 28, 2018).

Their conceptions of the STEM community were much more detailed compared to the beginning of the study, yet the evolution in their conceptions of the STEM community was not uniform. Their conceptions of the STEM community evolved based on their exposure to people in STEM and STEM experiences.

**Sense of Belonging**

The girls in the BAU case did not initially express a sense that they belonged in STEM. For instance, Ingrid and Penny, continuing with their initial drawings, highlighted
their family members as role models they have in STEM, yet neither of them was quite sure what they did beyond “working on math” (Ingrid Interview 1, November 2, 2018) and “making slime” (Penny Interview 1, October 3, 2018). Ingrid was not willing or interested in talking to a STEM professional because, “I can be shy” (Ingrid Interview 1, November 2, 2018). This was related to her disinterest in engaging with the STEM community, even those with whom she had existing relationships.

In contrast, Penny connected her mother to STEM because she “works on computers… at an office” (Penny Interview 1, October 3, 2018). Because of her familiarity with that work environment, Penny was willing to talk to other STEM people “if they’re nice,” wanting to ask “What do they learn about?” and “Where do you work for?” (Penny Interview 1, October 3, 2018). However, Penny was not willing to engage with others in STEM fields beyond her mother’s office. Remi, Bailey, Emily, and Ginny were all unsure if they would want to be around people with jobs in STEM because “I might be scared” (Remi Interview 1, November 1, 2018) because they “[didn’t] know anyone in STEM” (Bailey Interview 1, October 1, 2018).

Overall, the girls in this case did not mention many role models in STEM or people with whom they had close relationships that worked in STEM. Although they understood working in STEM is when “you fix [stuff]” (Remi Interview 1, November 1, 2018), the girls were cautious about engaging with the STEM community and did not feel like they belonged without a connection to others in the STEM community.

Emily was an exception, with her willingness to engage in conversation and relationship building with STEM professionals. Emily was excited to ask someone in
STEM, “Do you help people on the ground when they have a building that was like that far down… like crashed down?” (Emily Interview 1, October 1, 2018). Referencing a television show she watched where a building collapsed, and first responders came to help the victims. Although Emily’s conception of STEM differed from what I laid out for this study, how she was conceiving of STEM and the STEM community helped her express a sense of belonging. Emily wanted to know all about their jobs and felt comfortable asking questions and engaging in conversation.

Girls in the BAU case indicated many STEM-related places and objects from the photo sorts were definitively for boys. Images selected by all participants as boy items included robots, tools, and a construction site. The tools were used by “dads because they build” and “those are the workers” who use the tools at the construction site (Emily Interview 1, October 1, 2018). Ginny initially stated all of the items were for both, but changed her mind at the end, selecting these items as “mostly for boys, but girls might use them” (Ginny Interview 1, October 1, 2018). Only two participants indicated any of the items were for girls. Emily identified the bug kit was for girls because she “[owns] two of these things” (Emily Interview 1, October 1, 2018). Penny agreed, noting her neighbor had the “butterfly net” (Penny Interview 1, October 3, 2018). Penny also indicated the photos of iPads and mountains were for girls, but did not indicate why. Overall, the participants selected 18%-35% of the images as for boys while their range for girls was 0%-18%, indicating the girls may not feel like they belong in STEM as there was a masculine bent to their selections.
One week after the initial interview, participants in the BAU case did not express and a change in their sense of belonging. Like their initial interviews, girls continued associating STEM items with males in contrast to the female dominance in their drawings of the STEM community. This was significant because a sense of belonging was closely aligned with associating STEM items with your own characteristics, such as gender. Girls continued to indicate images of tools, construction, and robots were for boys, not girls, because they “see mostly boys doing that” (Emily Interview 2, October 9, 2018). Other images such as the spaceship, a toy medical kit, and lab coat were also commonly associated with boys.

The MagnaTiles and science center were the images selected for girls by one child. No other images were identified for girls after the STEM Princess Ball. On average, girls identified 3 of 16 STEM-related images for boys and 13 for both boys and girls. Children used their interactions with other children and their siblings to determine most of the items were for both boys and girls. For example, “Legos and iPads are for boys because [Ingrid] and [her] brother like to do those” (Ingrid Interview 2, November 27, 2018). Bailey and Ginny determined all of the images could be for boys or girls because “anyone can do anything they want” (Bailey Interview 2, October 9, 2018). Bailey’s mother spoke this exact same phrase several times in her second interview (Bailey’s Mom Interview 2, October 9, 2018), indicating the family members and role models in these girls’ lives were shaping their thoughts about belonging to the STEM. This indicated the girls did not have any changes in their sense of belonging and persisted
in associating STEM objects and places with boys over girls in spite of what messages others were telling them.

The girls did not express a sense of belonging to the STEM community even though many could think of one or more role models associated with STEM. Outside of who they already knew, the girls continued to be skeptical, but willing to talk to someone in the STEM community. Most of the girls only wanted to talk to someone in STEM “if they were nice” (Penny Interview 2, October 10, 2018) eluding to the perception people in STEM may not be the friendliest or most welcoming group “because it’s never happened” (Bailey Interview 2, October 9, 2018). The girls wanted to ask basic questions such as “how they work and if they like it” (Ginny Interview 2, October 10, 2018). Others wanted to only ask questions to STEM people “if I knew them” (Remi Interview 2, November 12, 2018). In these instances, girls wanted to ask about “things about my [homework] or something about my computer” (Remi Interview 2, November 12, 2018) and other issues related to their own lives. Their apprehension about engaging in conversation with someone in the STEM community through the second interview revealed the girls had a weak sense of belonging.

Over the four months of the study following the first and second interviews, the girls in the BAU case expressed a range in their sense of belonging. The girls in the BAU case initially did not feel comfortable talking to members of the STEM community. However, as our interviews progressed, the girls started gaining confidence in talking to someone with a job in STEM.
By the fifth round of interviews, all of the girls in the BAU case were willing to talk to someone with a job in STEM, a change from the first half of interviews when most of the girls were uncomfortable with these conversations. It is significant to note this may be due to a change in my questioning. Penny, among other girls, would only talk to a person in STEM “if they were nice” (Penny Interview 1, October 3, 2018). I realized they are at an age where they are wary of talking to strangers. I added the clause “if you knew they were safe” to the question: “If there was a grown-up who had a job in STEM and you knew they were safe, would you feel comfortable talking to them?” I changed the question after the third round of interviews. However, a change in feeling comfortable engaging with members of the STEM community did not occur until several interviews later, indicating there was an authentic change in the girls’ sense of belonging in the STEM community. Further, even though the girls expressed comfort in talking to someone in STEM, only some were interested in knowing about jobs in the STEM community and formulated insightful questions. This indicated the girls in the BAU case had an increase in their sense of belonging in STEM, but not all experienced an increased interest in STEM careers.

Some of the girls wanted to talk to members of the STEM community about STEM broadly while others were more interested in specific STEM jobs. Some of their questions were clarifying ones not specific to a job. Girls wanted to ask questions that would help them better conceptualize what STEM was by asking the experts, “what they learn in STEM and what they do in STEM” (Penny Interview 3, October 24, 2018). On an even more basic level, girls wanted to talk about “what does engineering mean?”
Bailey, Emily, and Penny wanted to ask for details about what people do in STEM jobs. Bailey wanted to know “how you build things and make things and do things” (Bailey Interview 5, November 28, 2018). Similarly, Emily had more specific questions related to her father who worked in dermatology where “he gets pimples out of them and spots that are bad” (Emily Interview 4, November 9, 2018). She wanted to know, “What do you do on their body? Do you help people? Do you use an iPad to help people if you can’t do it?” (Emily Interview 7, February 7, 2019). By the end of the study, Penny even wanted to ask if “I can have a job,” because she was now interested in STEM careers (Penny Interview 7, February 6, 2019). This enthusiasm and sense of belonging was not shared by all of the girls in the BAU case.

Emily wanted to be “just like [her] dad” who changed jobs and had a new office which was exciting for her family (Emily Interview 5, November 30, 2018). This sparked a new feeling that she was capable of being a doctor for Emily. Her connection to her dad gave boost in feeling a sense of belonging in STEM. She wanted “to help people and do stuff and help so I can get the office… just my own office” (Emily Interview 3, October 23, 2018). However, after the excitement and novelty had worn off with her dad as a role model, Emily bounced back and forth between a doctor and reverting back to “an art teacher… because I think I do good at art” (Emily Interview 6, January 7, 2019). In other words, Emily had a long-established sense of belonging in education and a strong sense of self-efficacy in art she expressed throughout the duration of the study. This created a
persistent attraction to being an art teacher instead of a wavering one like her attraction to medicine.

The girls in the BAU case provided further evidence of their sense of belonging in their choices of which photos related to STEM were for boys, girls, or both. Girls completed one or both photo sorts multiple times gendering a total of 32 images and justifying their choices. None of the objects were consistently identified as for girls. One image of hands holding a small tree was an activity the girls did with their mothers (Ginny Interview 5, November 29, 2018), plus “girls like to do plants… [and] that looks like girl hands” (Emily Interview 6, January 7, 2019). Another image of science equipment in a kitchen setting was selected as for girls by three participants because “girls like cooking more” (Ginny Interview 5, November 29, 2018). None of the girls consistently identified any of the images as feminine.

When both photo sorts were combined, the girls in the BAU case identified 2.68 images as for boys and .68 as for girls. The highest number of items identified for boys was six while the highest for girls was three. Images related to space, construction, and robots were all consistently associated with boys because “tools are used by boys” (Remi Interview 7, March 24, 2019). An average of 14.32 of the 16 objects in each set were identified as for boys or girls because “everyone can do everything” (Ingrid Interview 5, February 12, 2019), a statement repeated by several of the girls.

The messages the girls provided through the photo sorts contradicted each other. Although the girls were saying everything was available and for everyone, yet they indicated only boys were connected to STEM objects and locations. The contradictions
indicated the girls held conceptions of STEM that were masculine. However, the girls heard messaging that said it was for everyone. These messages left ambiguity about who belonged in the STEM community, including themselves.

**Self-efficacy**

The initial self-efficacy of the BAU case was shaped across the figured worlds in which they engaged and the lack of exposure to STEM. The only place girls in the BAU case connected to STEM was school and the lessons they completed with their teachers. Emily, for example, thought she was good at STEM because at school “I do good at art and computers” (Emily Interview 1, October 1, 2018).

The continued separation of STEM into science, technology, engineering, and mathematics was common when girls decided if they were good at STEM. As for STEM specifically, the girls had “never tried STEM” (Remi Interview 1, November 1, 2018), but guess they “may be [good at STEM]… I just don’t know” (Ingrid Interview 1, November 2, 2018). They realized their successes in school science, technology, engineering, and mathematics helped them conclude, “I think I am going to be good at it because I like everything [in STEM]” (Remi Interview 1, November 1, 2018). With little experience with STEM, the girls expressed confidence that they could be good at STEM, indicating they had strong self-efficacy overall. However, because they had not engaged in STEM, their self-efficacy specific to STEM was faint.

Limited self-efficacy in STEM led to few girls selecting STEM-related careers. Instead, girls were interested in careers where they had family or interaction with people in those careers. For example, Remi was considering “a police officer, a Hy-Vee worker,
a Walmart worker and a Target worker [because] I love those places and I like police officers and all the [store] workers. So, I just want to be them because it looks so cool to be it” (Remi Interview 1, November 1, 2018). Similarly, Emily “[liked] a lot of jobs” related to people she interacted with, but wanted to be a “police officer” because “they help people” or “babysitter like my mom” (Emily Interview 1, October 1, 2018).

Other role models, specifically those at school, were as important in career selection. Ingrid, Ginny, Bailey, and Penny all “[wanted] to be a teacher” (Penny Interview 1, October 3, 2018). Bailey “[wanted] to be an actress… or teacher, maybe 2nd grade” (Bailey Interview 1, October 1, 2018). They were interested in careers they knew about and had connections to people in those fields, which seemed to create a feeling that they could also succeed in those fields.

In our second interview, some children in the BAU case said they had not done any STEM activities before and others were not sure if they even liked STEM. However, every child in the BAU case knew they were good at STEM based on their experiences at school. “Every day we do blank math sheets and we get to do technology, math, and games… like penny-nickel exchange and homework” (Ingrid Interview 2, November 27, 2018). Their successes in school increased their STEM self-efficacy. When they had not done a STEM-specific activity, they knew they could do “science and math” (Ginny Interview 2, October 10, 2018) and when “I know two of the things, and then I’m getting into the other two things,” (Remi Interview 2, November 12, 2018) the girls reasoned they were good at STEM as a whole. After all, they must be good at STEM if they think
“[STEM] is fun” (Bailey Interview 2, October 9, 2018) and like “that it’s fun to do” (Ginny Interview 2, October 10, 2018).

Girls’ career choices were aligned to their other expressions of self-efficacy. The careers they were interested in centered around their role models and past experiences. For instance, Remi wanted to be “a teacher because I know someone in my family that is a teacher, my aunt Stephanie” (Remi Interview 2, November 12, 2018). Their role models and feeling like school was a place where they were successful made teaching a popular choice. A few of the girls wanted to be teachers that specifically related to STEM. Ginny wanted to be “a teacher… that does math” (Ginny Interview 2, October 10, 2018), and Ingrid wanted to be “a teacher [who plays] math games with my students” and “because I like doing arts and crafts” (Ingrid Interview 2, November 27, 2018). However, experiences outside of school and interests also shaped their self-efficacy and career choices.

Bailey, like the other girls, was deciding on a career based on what she felt good at, an indicator of self-efficacy. Bailey wanted to be “an actress… one for plays because I like to do stuff then act like something” because this is what she witnessed on her favorite YouTube show (Bailey Interview 2, October 9, 2018). Penny wanted to “help people if they need a house or make stuff… like an engineer” (Penny Interview 2, October 10, 2018). Her further elaboration revealed she did not really want to be an engineer because she wanted to paint and design interiors of homes with crafty items she made, not design and build the house. She was confused on what an engineer does in their work. However, Penny was the only one who specifically mentioned a STEM career. The BAU
participants, as a whole, were ambiguous about STEM careers even though they all also said they thought they were good at STEM. There disconnect from STEM careers suggests the BAU case did not have strong STEM self-efficacy.

The girls’ STEM self-efficacy focused on their classroom performance and did not extend into doing STEM more broadly. However, there was little expression of STEM self-efficacy outside their school experiences. “When I hear STEM, when you hear that stuff, it means a school, so I feel like you’re building words and stuff” (Remi Interview 7, March 24, 2019). The girls in the BAU case referenced doing “a good job in math” (Ingrid Interview 3, January 8, 2019), or “[doing] good at art and technology” (Emily Interview 5, November 30, 2018). They were good at STEM only when they “do some stuff sometimes in my classroom when I’m at school” (Remi Interview 7, March 24, 2019).

The girls who were in classrooms with STEM lessons expressed more STEM self-efficacy than those who did not have STEM in their classrooms. Experiencing success in a STEM-specific lesson was a powerful force for developing their self-efficacy in and outside of school. They were good at STEM “because I practice and do it a lot of times” (Ginny Interview 3, November 5, 2018) and “because I do it on every Friday” at school (Bailey Interview 7, February 4, 2019). Instead of being good at STEM, girls often mentioned the silos related to STEM stating things like “I’m good at science and I’m good in math” (Penny Interview 4, November 9, 2018).

Only Penny connected her school lessons to being good at STEM outside of school. Engaging in STEM in any context translated into increased self-efficacy in other
settings. For example, Penny “[liked] doing engineering” like when “we made boats out of tin foil and a plastic plate, tape, and pennies… We built it and we tried to see who had it on the water the most” (Penny Interview 4, November 9, 2018). She connected this to building sand castles at her grandma’s house “because pretty much building a castle is kind of like STEM” (Penny Interview 5, November 20, 2018). Penny felt like she was good at STEM because she had the opportunity to experience success. Access to STEM was critical to building their STEM self-efficacy.

Ingrid expressed she was able to do STEM “because I do math, technology… and science too. I like art stuff,” so that made her feel like she could be successful at a STEM career (Ingrid Interview 4, February 5, 2019). However, that did not translate to wanting a career in STEM. Ingrid wanted to be “an art teacher or a first-grade teacher” the entire duration of the study even though she would consider “engineering” because she “[likes] fixing stuff. We are building a movie theater in our basement… my dad and my brother” (Ingrid Interview 5, February 12, 2019). Even though she had STEM self-efficacy, an art teacher continued as her primary career interest “because I like teacher people stuff and I like art” (Ingrid Interview 7, March 22, 2019).

Like Ingrid, Remi and Bailey believed they could have jobs in STEM and expressed self-efficacy related to STEM, but these girls were not necessarily interested in a STEM job. Bailey expressed no interest in STEM careers. She wanted to use her creative energy as “an actress” (Bailey Interview 3, October 25, 2018) or “interior designer… because I like to design things for other people” (Bailey Interview 6, January 15, 2019). Even though she stated she did not want to go into a STEM career, Bailey’s
goal as an interior designer was to “make furniture and sell it” (Bailey Interview 6, January 15, 2019). Somehow this was not STEM to Bailey even though the very reason she identified her grandfather as a person in STEM was because “he uses science and technology and math… and engineering to create a lot of the wood projects he does” like making furniture (Bailey Interview 5, November 28, 2018). The existence of STEM self-efficacy expressed by Ingrid, Bailey, and Remi did not translate to their pursuit of STEM careers.

The girls’ career choices were driven by who they considered to be role models. Parents, teachers, siblings, and community members were all mentioned as people the girls looked up to and influenced their career choices. Their role models were central in determining which careers were a good fit for them. For example, Bailey wanted to be an interior designer because “first Emma (her big sister) wanted to do it… then Emma stopped because she heard that I wanted to do it” (Bailey Interview 6, January 15, 2019). She did not have any interest in STEM, but also mentioned, “I don’t know anyone” (Bailey Interview 5, November 28, 2018) in STEM.

Teaching was the most popular career choice and one of the most salient sources of role models in the girls’ lives. Their current and/or favorite teachers were an important connection to how they made their career choice. However, the girls did not make connections between teaching and STEM on their own indicting their career choices were not related to their STEM self-efficacy. For instance, Ginny and Remi both wanted to be “a teacher… for second grade because my second-grade teacher, Mrs. Anderson, is really nice” (Ginny Interview 5, November 29, 2018). Education was a great experience for
these girls which made them believe teachers get “to meet new people and have fun with
them” (Remi Interview 7, March 24, 2019). Even when asked if they would specifically
be interested in a STEM job, they wanted to be “a math teacher” (Remi Interview 7,
March 24, 2019) or “join math clubs” (Penny Interview 7, February 6, 2019) instead of
selecting a job outside of education. This focus on education over STEM coupled with
their answers to talking to STEM people indicated their STEM self-efficacy was more
specific to the school setting and did not extend into the broader STEM community.

Interest

Girls had varying interests in STEM during our first interviews. When asked what
they liked to do and play with, girls did not mention any toys or activities related to
STEM instead focusing on trinkets like Squishies, playing school, and a variety of sports.
Girls also mentioned doing crafts, watching television and YouTube, and coloring.
Multiple girls mentioned playing with Legos, but none of them believed they were related
to STEM. In fact, none of the BAU participants mentioned being interested in STEM or
anything they related to STEM without being probed about STEM. When specifically
asked about STEM, the girls said they liked STEM “because it’s fun” (Emily Interview 1,
October 1, 2018). However, the girls were not able to give any examples of what in
STEM was fun or interesting.

The girls’ interests in STEM were connected to the school experiences like their
self-efficacy. Ingrid enjoyed STEM because “I like playing math games and being on the
computer” (Ingrid Interview 1, November 2, 2018). This dividing of STEM into
individual school subjects was a common response when discussing their interest in
STEM. Several girls only liked some of the individual subjects. For example, Penny “only [liked] science and math” because “at school we learn about secrets in science and then in math we do games and math boxes” (Penny Interview 1, October 3, 2018). Even Ginny, who did have STEM Fridays at school, expressed an interest in STEM, but referred to “I like math and doing hard problems” when elaborating on her interests in STEM (Ginny Interview 1, October 1, 2018). Again, the girls expressed interest in STEM, but their elaboration indicated their interest was still developing.

A wide range of interest in STEM surfaced in the second round of interviews. As stated above, some of the girls struggled to articulate their conceptions of STEM, leading to expressing interest in activities, experiences, and events that were not associated with STEM, yet calling them STEM. The lack of clarity around conceptions of STEM led to some confusion about interest in STEM. Remi knew STEM was interesting “because in STEM I like the projects because they’re my favorite… I make new stuff: new words, new stuff, new things, and new writings. New everything!” (Remi Interview 2, November 12, 2018). Though Remi stated she likes STEM, her relation of building as in spelling words and writing does not align to this study’s conception of STEM.

Similarly, Penny and Emily were excited about STEM, but made connections to activities and interests outside of STEM which was reflective of their misconceptions discussed previously. In particular, they wanted to work more on making. However, both envisioned “making” as being creative with art. Penny liked “making stuff… drawing pictures” with “art crayons, or art colors, and I like chalk… I have a chalkboard in my room and I like sidewalk chalk too” which led her to the conclusion that she was
interested in STEM (Penny Interview 2, October 10, 2018). Likewise, Emily “[liked] art… and reading a lot of fun stuff,” which is a kind of creativity, but not the making and creating associated with STEM (Emily Interview 2, October 9, 2018).

Bailey and Ingrid struggled to decide if they were interested STEM or not. Bailey and Ingrid particularly liked the “little projects… and the games [in math],” yet they were not as sure as the other girls that they liked STEM (Ingrid Interview 2, November 27, 2018). Ingrid was “maybe” interested in STEM “because I like math… and doing arts and crafts” (Ingrid Interview 2, November 27, 2018). However, without much experience or exposure to STEM as its own subject, Bailey and Ingrid were tentative about their interest in STEM inhibiting them from further pursuing STEM experiences.

The toys and activities girls were interested in included some STEM items. However, most of the girls’ favorite things to do and play were not STEM-related. The only toy or activity connected to STEM mentioned by more than one participant was Legos. All other interests fell outside of STEM. The girls mentioned they liked many toys common in popular culture such as “Squishies” (Ginny Interview 2, October 10, 2018) and “Barbies” (Bailey Interview 2, October 9, 2018). Sports such as “dance and soccer” (Bailey Interview 2, October 9, 2018) were popular, as well as “playing on our iPads” (Remi Interview 2, November 12, 2018). However, the girls did not mention any STEM-related iPad games. For example, Penny “[likes] to play on my iPad… dressing girls… and mermaids (Penny Interview 2, October 10, 2018). You do their clothes and their makeup and their hair.” Other creative activities like “doing arts and crafts” (Ingrid Interview 2, November 27, 2018) or “drawing pictures and writing things” (Remi
Interview 2, November 12, 2018) were popular. Finally, all of the girls mentioned a love for games, stuffed animals, dolls, and playing with friends. They also enjoyed being with other kids where they “like to play pretend dogs” (Emily Interview 2, October 9, 2018) or “make funny faces at our friends and then they laugh” (Remi Interview 2, November 12, 2018). While their interests were broad and encompassed many areas, STEM was not at the forefront for any of the girls and was largely absent as a point of interest.

Throughout the rest of the study, all of the girls in the BAU case said they were interested in STEM to some degree. School and life events were the most commonly discussed reasons they liked STEM. For example, Ingrid “[loved] technology and math and engineering because we were doing stuff in school” (Ingrid Interview 4, February 5, 2019). Ingrid suddenly liked animals and wanted to be a vet because she had just received a puppy for a Christmas gift (Ingrid Interview 5, February 12, 2019). However, this interest passed by the next interview two weeks later, returning her interests to art and math because “I do school math and sometimes at home” (Ingrid Interview 7, March 22, 2019).

This ebb and flow in interests related to STEM was common among the other girls in the BAU case. Like Ingrid, Ginny was interested in STEM “because it’s fun and… writing and math are my favorite subjects” (Ginny Interview 3, November 5, 2018). Her interest was specifically peaked when her class “built a catapult with a ruler, rubber band, masking tape, a spoon, golf ball, and cotton ball” (Ginny Interview 5, November 29, 2018). However, at other times Ginny was not interested in STEM “because I don’t really like technology and I don’t really want to try to do it. I don’t
really understand engineering that much” (Ginny Interview 5, November 29, 2018).

Overall, the girls “kind of” liked STEM, but “not a lot” (Bailey Interview 7, February 4, 2019).

What the girls were interested in was reflected in their choices of toys and what they liked to play. Often the girls mentioned different toys and activities during each interview that were similar, but also connected to how their interests were changing with life events. For instance, Ingrid liked “playing with my stuffed animal dog” which looked like her new puppy (Ingrid Interview 7, March 22, 2019). Similarly, Emily liked “to go to water parks and like to go to a hotel and parks” just after she had spent a weekend with her family at a local hotel with an attached water park (Emily Interview 6, January 7, 2019). Their immediate experiences were at the forefront when they were answering. None of the girls mentioned STEM activities they engaged in when discussing what they liked to do or how they wanted to spend their time.

Legos and technology continued to be the only toys or activities connected to STEM that was regularly mentioned by the girls in the BAU case. The girls did not make the connection between STEM to Legos and technology on their own. Legos were for playing with blocks (Ingrid Interview 4, February 5, 2019) not necessarily for creating structures or building. They liked technology because “you get to play games on the computer” (Bailey Interview 5, November 28, 2018), “play games on my phone” (Emily Interview 5, November 30, 2018), or “watch [shows on] my iPad” like “Cake Wars” or “Nailed It” (Bailey Interview 5, November 28, 2018). Only Ginny mentioned she would “probably [do] science experiments” if she could pick what she wanted to do for a whole
day. When other girls liked “making stuff,” it was not STEM-related, but rather crafts like “pictures for people and bracelets” (Penny Interview 3, October 24, 2018).

More popular than STEM activities and toys were stereotypically female activities related to beauty and nurturing. All of the girls mentioned playing with dolls and dressing up in some fashion. Remi, for instance, liked playing with “American Girl dolls… and baby dolls” (Remi Interview 4, February 1, 2019). Other girls wanted to spend their time “[painting] my nails” (Ingrid Interview 5, February 12, 2019) and dressing up with “a lot of jewelry and stuff” (Remi Interview 4, February 1, 2019). This correlated to what was on their gift lists which was dominated by things like “bath bombs, cute backpacks, headphones non-Bluetooth, earrings, jewelry… cute clothing, Justice gift cards, Claire’s gift cards, athletic headbands, athletic clothes, a pet, and make up” (Penny Interview 4, November 9, 2018). The BAU case also mentioned stereotypically female activities such as wanting to “stay at home and play with [a baby]” (Emily Interview 6, January 7, 2019) or a “baby brother” (Ingrid Interview 7, March 22, 2019), and “doing crafts like [sewing]” (Ginny Interview 5, November 29, 2018). Throughout the duration of the study, the girls in the BAU case did not emphasize STEM when discussing their favorite toys and how they want to spend their time, indicating there was little change in their level of interest in STEM.

Conclusion

The girls in the BAU case expressed some connections between themselves and STEM. However, their personal interests, self-efficacy, and sense of belonging related to STEM varied greatly without consistent access to STEM. The girls engaging in STEM at
school did express developing conceptions of STEM and the STEM community that allowed them to form stronger self-efficacy and a sense of belonging as well as increased interest. Perhaps the most significant finding within the BAU case was the importance of access regardless of in which figured world it took place. The girls were able to draw upon experiences at school to begin building STEM identities that translated outside of school. However, these opportunities to engage in STEM did not change their conceptions of the STEM community as masculine.

**Cross Case Analysis**

The STEMP and BAU cases were bounded by participant demographics. Girls in both cases had similar STEM experiences prior to beginning the study. Both cases engaged in STEM an average of three to four times per month with a range of one to seven times per month. Parents from both cases reported STEM engagement occurred in formal and informal environments, as well as at home. Regardless of their STEM engagement and comfort, all of the girls were initially timid, yet excited to engage with me and participate in the study. However, the BAU case was notably more reserved than the STEMP case. I wrote in my field notes (October 1, 2018),

I found it interesting the BAU kids have fewer questions, but also seem more skeptical of me and what we are doing. The STEMP girls just seem more comfortable. I think this is because they already know about and are discussing the STEM Princess Ball while the BAU girls and I do not have this established connection. I do not think there is an inherent difference in personalities or interests between the groups.
In other words, the girls in the BAU case did not have the connection between me and the STEM Princess Ball that the STEMP case had, leading to more apprehension in the initial interviews with the BAU case. The differences were resolved by the second interview when children from both cases greeted me with enthusiasm. Their excitement about the study endured throughout our interviews about their conceptions of STEM and the STEM community, sense of belonging, self-efficacy, and interests. These themes were central to addressing my research questions using the lens of figured worlds.

Central to identity development in the figured worlds framework is the cyclical nature of identities in practice. The STEMP and BAU cases started the study with similar existing identities: female, White, middle class, and from two-parent, educated households. While the STEMP and BAU cases were bounded by their existing identities, the girls in the STEMP case engaged in the STEM Princess figured world designed to situate and empower them as females in STEM. While all of the figured worlds participants from both cases engaged in have the power to shape their STEM identities, the STEM Princess figured world uniquely empowered the STEMP case by providing access and opportunity to engage in dialogue and embody STEM practices that were specific to their existing interests and identities, paving the way for resolving conflicting conceptions and roles associated with STEM (see Figure 68). Holland, Lachicotte, Skinner, and Cain (1998) refer to the process of resolving conflicts, improvising, and practicing as self-authoring. The process of self-authoring is critical to building conceptions, sense of belonging, self-efficacy, and interest related to STEM that are the core of identity formation. Identities are always in practice and in the process of forming.
The similarities and differences in the STEM identities across the BAU and STEMP cases are aligned with identities in practice from Holland, Lachicotte, Skinner, and Cain (1998). Ongoing access and engagement with role models, content, and positive experiences related to STEM within and across figured worlds is the catalyst for self-authoring and STEM identity formation.

Figure 68. Representation of adding the STEM Princess into the figured worlds of participants in the STEMP case.

Conceptions of Gender

The STEMP and BAU cases were bounded by the demographics of the participants as well as time. While the cases were not bounded by their conceptions of gender, I needed to make sure children’s conceptions of gender were similar across cases.
because my research questions aimed to understand the influence of a female-centered figured world on STEM identity development. I wanted to know how children were conceiving of masculine and feminine for the purposes of making claims regarding the influence of the gendered figured world on STEM conceptions, I needed to ensure the participants conceptions of gendered aligned across the participants.

In order to gain a deeper understanding of the girls’ conceptions of gender, each child drew a picture of a boy and another of a girl. The drawings of girls unanimously included long hair. Other consistent features were dresses, high heel shoes, flowers, and long eyelashes (see Figures 69 and 70). The drawings of boys, in contrast, unanimously included short hair, no eyelashes, and fewer details on their clothing. Other common features included sports equipment and animals particularly dinosaurs (see Figures 71 and 72). Though the presence or absence of a “penis” (Rose Interview 6, January 8, 2019) and other specific body parts were mentioned by several participants, the girls focused on their conceptions of gender based on outward appearance including hair styles and clothing.

When asked how participants knew the person in their drawings was a boy or girl, the girls stated because they have “short hair or long hair” (Reagan Interview 6, January 13, 2019). Other common responses were about clothing, especially “wearing a dress” (Carrie Interview 6, January 23, 2019) for girls and “baggier, athletic stuff” (Ingrid Interview 5, February 12, 2019) or “work [clothes]” (Emily Interview 6, January 7, 2019) for boys. While participants stated boys and girls enjoy “building with Legos” (Emily Interview 6, January 7, 2019; Harper Interview 6, January 17, 2019; Rose Interview 6,
January 8, 2019) and “playing basketball” (Ingrid Interview 5, February 12, 2019; Eden Interview 6, January 8, 2019), the conceptions of what girls like that boys do not emphasized physical appearance. For example, “[girls have] longer lashes than [boys]” (Ginny Interview 6, January 23, 2019; Harper Interview 6, January 17, 2019) and “like to have their nails painted” and “wear nice clothes… [looking] fancier than boys” (Carrie Interview 6, January 23, 2019) with “flowers and butterflies and… unicorns” (Eden Interview 6, January 8, 2019). In contrast, conceptions of what boys like emphasized activities and interests. Boys like “[playing] football, baseball, and basketball” (Carrie Interview 6, January 23, 2019). The children also consistently associated boys with STEM-related items such as “dinosaurs and cars” (Eden Interview 6, January 8, 2019) as well as interacting with technology such as “watching TV” (Reagan Interview 6, January 13, 2019) and “playing Fortnite” (Harper Interview 6, January 17, 2019).

Figure 69. Eden’s drawing of a girl.  
Figure 70. Remi’s drawing of a girl.
There was not a stated conception that males and females have different skills, jobs, or abilities. None of the girls identified jobs or skills only men/boys or only women/girls could do. However, participants identified the phenotypes of gender common to US society which drove their conceptions of gender and associated roles. This resulted in a distinct gap between STEM-related objects and preferences associated with girls when compared to boys. Boys and men “do tools… and the farming” (Penny Interview 7, February 6, 2019) according to most of the girls. Emily explicitly stated only boys “do work. They might like to do other stuff like science and art and math… Mostly girls don’t work… [girls] watch their phones” (Emily Interview 6, January 7, 2019). Although one child drew a female in a STEM setting with a lab coat and safety goggles, I quickly discovered it was the STEM Barbie she received as a gift for her birthday (Bailey
Interview 6, January 15, 2019). Bailey stated the girl in her drawing liked to play with friends and babysit bees, not mentioning STEM or other related activities. It was the ultra-femininity of Barbie that inspired Bailey to use her as a model of a girl.

Participants’ conceptions of gender were similar across cases. This was crucial because my research questions aimed to understand the influence of a female-centered figured world on STEM identity development. Participants’ conceptions of masculine and feminine were foundational to how they were making connections between STEM and gender. The continuity of participants’ conceptions of gendered across the cases allowed me to eliminate differences in the girls’ conceptions of gender as an influence on their STEM identity development and pursue the answers to my other research questions.

The following sections compared and contrasted the STEMP case with the BAU case. More specifically, I answered the overarching research question by first answering the following subquestions.

- What conceptions do participants have of STEM before and after engaging in all-female STEM experiences compared to peers who do not engage in the same or similar experiences?
- How are STEM sense of belonging and self-efficacy of participants influenced by engaging in all-female STEM experiences compared to peers who do not engage in the same or similar experiences?
- How does engaging in all-female STEM experiences influence the interests of participants compared to peers who do not engage in the same or similar experiences?
I answered the subquestions by comparing and contrasting the STEM Princess and Business as Usual cases. I focused on the points of congruence and departure across cases. I organized this process through analyzing each stage of the study followed by the overarching experiences. The patterns of identity development constructed in the cases were critical to answering all of my questions in order to understand if the identities in practice of the STEM Princess case were the same as to the Business as Usual case. The cross-case comparisons provided insight into the influence participating in the STEM Princess figured world did and did not have on the STEM identity development of young girls. Finally, I looked at alternative propositions.

What conceptions do participants have of STEM before and after engaging in all-female STEM experiences compared to peers who do not engage in the same or similar experiences?

The STEM conceptions held by children from both cases were just beginning to develop at the time of the initial interviews. Girls in the STEM Princess (STEMP) and Business as Usual (BAU) neither knew what STEM stood for nor could they provide a description of what STEM entailed. The lack of response implied none of the girls held conceptions about STEM when the study started. However, after hearing a standardized prompt defining STEM, girls in the STEMP case provided more details compared to the BAU case. The STEM Princess case made connections to their schoolwork, as well as described their conceptions of what it looked like to do STEM. In contrast, the BAU participants indicated they understood what I said without any elaboration or connections as evidence that they did indeed grasp what STEM was. The difference in their responses to the provided prompt indicated the
STEMP case had more conceptions about STEM at the beginning of the study when compared to the BAU case. This is likely related to having parents who sought out STEM events like the STEM Princess Ball for their child. Their experiences, while equal in frequency, may have been richer or more rigorous, sparking the development of STEM conceptions, albeit still limited.

Conceptions of STEM held by the STEMP case were notably deeper than the BAU case by the end of the study. Girls in the STEMP case made personal connections to STEM, resulting in a fondness for STEM and conceptions with a positive connotation. While STEMP participants could easily provide the words science, technology, engineering, and mathematics, their descriptions were also comprehensive including building, creating, problem solving, inventing, and more. Significantly, their STEM conceptions connected experiences and knowledge from multiple figured worlds, indicating they were able to abstract their conceptions of STEM into multiple settings over the course of the study, showing the STEMP case had conceptions evolving around STEM as a versatile metadiscipline.

The first prominent change in conceptions of STEM occurred after the STEMP case experienced the STEM Princess figured world by attending the STEM Princess Ball. Not only were girls in the STEMP case able to define the acronym STEM, they also enthusiastically described what it looked like to do STEM and how STEM made them feel: eager and jovial. The conceptions held by the STEMP case were dramatically different than those of the BAU case who struggled to provide the words that make up the STEM acronym, especially engineering. The BAU participants largely did not have
conceptions of what it looked like to do STEM. In fact, the opposite was true. BAU participants shared their conceptions of STEM as challenging and difficult, though this conception diminished by the end of the study.

BAU participants held many misconceptions of STEM, such as equating STEM to art. The girls in the BAU case also did not report any additional engagement in STEM in any of their figured worlds between the first and second interview. Only Bailey, who discussed STEM with her mother, had a notable increase in her development of STEM conceptions, indicating access and opportunities to engage in STEM within and outside of the STEM Princess figured world were critical to developing rich conceptions of STEM. However, how the girls repeated parts of the prompt I provided indicated just the interviews had a minor influence on their conceptions of STEM.

The BAU case continued to rely on the prompt I provided as their definition of STEM. Their conceptions beyond that were limited unless they participated in STEM in another figured world. Ingrid and Emily, who reported no additional STEM interactions, held conceptions that remained limited and peppered with misconceptions throughout the duration of the study. In contrast, the conceptions held by Penny, Bailey, and Ginny developed as they engaged in robust STEM experiences at school. Remi, who also engaged in STEM at home, also expressed more robust conceptions of STEM. However, it is important to emphasize their conceptions of STEM were not as accurate or dynamic as those expressed by the STEMP case, even though they engaged in STEM through other figured worlds. The conceptions of STEM held by the BAU case remained limited
to the standardized prompt or their siloed school subjects, not the metadiscipline conceptualized in this study.

Overall, both cases provided evidence of STEM conceptions in progress. Engaging in STEM, regardless of which figured world it occurred, influenced the conceptions of STEM the girls held. More specifically, STEM experiences provided a foundation for the girls to begin forming STEM identities. The STEMP case conceptions of STEM were more closely aligned to the identities in practice Holland, Lachicotte, Skinner, and Cain (1998) described. Their conceptions were personal, connected to other figured worlds in which they engaged, and each expressed a positive emotional connection to STEM. Each of these, particularly the enthusiasm and enjoyment associated with STEM, are markers of STEM identity development that were not present in the BAU case, indicating engaging in the STEM Princess figured world positively influenced the conceptions of the participants in ways the BAU case did not articulate.

The division that emerged between the two cases in their conceptions of STEM also emerged in the conceptions of the STEM community held over the course of the study. Both cases began with conceptions of the STEM community that relied heavily upon people in their lives, with the majority drawing female figures. Girls from both cases initially drew images of babysitters, teachers, and family members. They also drew more cartoon-like figures with stereotypical STEM imagery including lab coats, safety goggles, and technology. Significantly though, none of the girls provided details on why the person in their drawing was a STEM person or how their conception of STEM was linked to what the person in the drawing was doing. The descriptions of the drawings
were vague, explaining they were doing an experiment, fixing, or working. Their
drawings point to initial conceptions of the STEM community that were as vague and
uncertain as their conceptions of STEM with the exception of gender. The images
indicated both cases shared a conception of the STEM community as female-dominated.

The conception of femininity related to the STEM community persisted to the end
of the study in the drawings of girls from both cases. The final drawings of STEM people
were all females with the exception of one girl from each case. Like their initial
drawings, the drawings from both cases featured people they were familiar with or
cartoon-like characters. Images from Ginny, Remi, Hannah, and Harper, girls from both
cases, all depicted individuals who were working in a particular silo of STEM: science,
mathematics, technology, and engineering respectively. Their drawings closely aligned to
their conceptions of STEM which included them describing STEM by repeating science,
technology, engineering, and mathematics or relating it to the siloed school subjects of
the same names and incorporating the ideas of building and fixing.

The BAU case participants largely created drawings of STEM persons that
remained consistent throughout the study. Only Remi and Bailey, who experienced
STEM in other figured worlds, created drawings with new schema. Remi drew an auto
mechanic and Bailey STEM Barbie. However, Bailey and Remi’s misconceptions about
STEM were present in their drawings. One the other hand, Emily drew images related to
art in all three of her drawings, consistent with her misconception of STEM as creating
art. Remi drew a mechanic working on a car, a common conception related to STEM that
does not align with those this study. While their drawings did support the findings on
their conceptions, they also provided further insight into how stereotypical items and places related to STEM dominated their thinking throughout. The final drawings of the BAU case continued to emphasize material items such as flasks, lab coats, and tools that are stereotypically associated with science and technology, indicating their conceptions of the STEM community remained relatively steady.

Like their initial drawings, the girls in the BAU case were unable to provide evidence for why their figures were people in STEM beyond the surface. For example, Ingrid drew her mother, who she knew worked with mathematics, but she did not explain the duties of her mother’s career or state her mother was an accountant. The BAU case participants’ lack of explanation and relatively steady portrayals of the STEM community revealed a stagnant conception of the STEM community. The parallel between their persistent conceptions of STEM and the STEM community signified the importance of exposure to STEM to progress conceptions. When exposed to STEM, Bailey and Remi exhibited a change in their conceptions of STEM and the STEM community that aligned within the other data points Bailey and Remi provided, but was a departure from the rest of the BAU case, Penny, Emily and Ingrid, who were not exposed to STEM. Unlike their conceptions of STEM, our biweekly interviews were not enough to influence their conceptions of the STEM community. In other words, the girls in the BAU case exhibited stagnant conceptions of the STEM community, not conceptions in practice, because their exposure to STEM in their figured worlds limited their opportunities and access to do so.

The STEMP case produced final drawings featuring dramatically different conceptions of the STEM community compared to their initial drawings. Their final
drawings featured individuals inventing and creating. Other drawings only featured a person without any background signifying they did not need to feature stereotypical STEM imagery like flasks and computers. The girls drew the person and described why their careers, interests, and histories aligned them with the STEM community. While the drawings continued to rely on persons with whom they had relationships, their drawings merely served as a jumping point for the girls to share rich descriptions of the STEM community. Like their conceptions of STEM, their conceptions of the STEM community did not remain siloed like the initial drawings and descriptions. Their final drawings featured individuals applying a multitude of skills and knowledge to a variety of fields from sports to computer engineering.

The final drawings from the STEMP case included some stereotypically STEM objects, but the girls explained why they included them in their drawings as an important component of STEM. For example, Carrie’s figure was holding a wrench because it was building and programming a robot (Carrie Interview 7, February 6, 2019). The wrench was necessary for tightening the bolts of the robot and accessing its wires for programming. Similarly, Harper drew a figure wearing a lab coat and glasses who was experimenting, building, and engineering (Harper Interview 7, February 3, 2019). Though much of her drawing was of stereotypical images, she provided a detailed description of her figure, creating a cohesive conception of STEM work. This was a significant departure from her first and second drawings where a hodgepodge of stereotypical STEM images (e.g. factory, construction tools, cars, and laboratory equipment) were all in the same drawing, making it difficult for her to provide a
cohesive, sensical explanation. The shift in the coherence in their drawings and descriptions illustrated the growth children in the STEMP case experienced over the course of this study. The consistent engagement in the STEM Princess figured world provided the STEMP case with a variety of role models and careers. The girls in the STEMP case used their experiences with the STEM Princess to develop their conceptions of the STEM community.

The evolution of the conceptions of the STEM community held by the STEMP case happened over the course of their engagement in the STEM Princess figured world. There was a marked difference between the initial drawings from the STEMP case and those created after attending the STEM Princess Ball where they experienced the STEM Princess figured world for the first time. Their second drawings depicted people, places, and objects related to the activities they completed with the STEM Princess and the role models with whom they interacted at the STEM Princess Ball. However, because the STEM Princess Ball capitalized on the stereotypical clothing and objects associated with STEM, some of their drawings included more stereotypical imagery in their second drawings compared to their first. For example, Harper changed her drawing from an auto mechanic to a scientist. Although both images were common conceptions related to stereotypical STEM locations, the change indicated Harper’s conception of the STEM community was influenced by her participation in the STEM Princess as many of the role models were dressed in similar attire. The direct correlation between the changes in their drawings and the STEM Princess figured world highlight the influence the STEM Princess had on the conceptions of the STEM community the girls in the STEMP case
held. The changes in their drawings and the connections to their engagement in the STEM Princess indicated the influence continued throughout the study. The STEM Princess figured world gave STEMP participants a chance to practice and refine their conceptions of the STEM community.

The differences between the conceptions of the STEM community presented by the STEMP and BAU cases were echoed in their selections of images from the Pick-a-STEM-Person Test. Like their drawings, the images girls in both cases selected were predominantly female from the beginning to the end of the study. None of the girls from either case pointed out or discussed their preference toward females at any time in the study. Only Emily selected more males than females in her final PASPT, justifying her choices based on her role models in STEM, a male teacher and her father. The seemingly unintentional partiality toward females indicated an unconscious bias present in the conceptions of the STEM community held by both cases. An alternative rationale is in-group preferences common to this age group. Perhaps more females were selected simply because all participants were females.

Children in both cases rationalized their choices on the PASPT using the presence of stereotypical objects and places such as labs, science equipment, and clothing such as a lab coat. Demographic features such as gender and race did not dominate their conceptions of the STEM community during any stage of data collection. In the final completion of the PASPT, Rose, a participant in the STEMP case, mentioned picking girls when unsure because she was a girl. No other child mentioned sex as a factor in
their choices. Instead all children, including Rose, focused on the presence of STEM-related clothing, lab equipment, and other STEM items such as rockets and medical tools.

The nuanced differences between choices the STEMP and BAU cases made on the PASPT provide further insight into their conceptions of the STEM community. Even though both cases gave preference to females and persons in a STEM context, there were differences in their selections. Table 5 provides the ratios of how the STEMP and BAU cases connected people from the PASPT to STEM or not. The ratios emphasize the dramatic shift in the STEMP case’s selections compared to the BAU case. The STEMP case selected more females over males after participating in the STEM Princess one time (see highlighted cell). The same shift in selections was not present with the BAU case. Additionally, there was not a dramatic change in the average ratios between images with STEM and neutral contexts. The dominant preference for females was present throughout the duration of the study for the STEMP case but was tempered by the end.

*Table 5. Comparing the ratios of selections based on image characteristics of the STEMP and BAU cases.*

<table>
<thead>
<tr>
<th>Image Characteristics</th>
<th>Case</th>
<th>Stage 1 Average (Initial)</th>
<th>Stage 2 Average (After STEM Princess Ball)</th>
<th>Stage 3 Final Average (Study End)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BAU Case</td>
<td>19:9</td>
<td>18:10</td>
<td>21:7</td>
</tr>
<tr>
<td>Ratio of Male vs. Female</td>
<td>STEMP Case</td>
<td>13:15</td>
<td><strong>10:18</strong></td>
<td>11:17</td>
</tr>
<tr>
<td></td>
<td>BAU Case</td>
<td>13:15</td>
<td>13:15</td>
<td>12:16</td>
</tr>
</tbody>
</table>
The change in average rate of selecting females over males that was unique to the STEMP case provided further evidence the STEM Princess figured world influenced the conceptions of the STEM community held by the STEMP participants. The female-centered figured world shifted their conceptions further toward females, implying it was not just an in-group preference but a true change in how they were conceiving the STEM community. Participating in the STEM Princess provided the STEMP case a wealth of role models, experiences, and dialog for the STEM case to re-author their STEM identities in practice that was not evidence for the BAU case.

Overall, the STEMP and BAU cases started with similar conceptions of STEM and the STEM community. Based on the similarities in their demographics, this fits with the concept of how identities form in practice through figured worlds. The STEMP case initially provided slightly more evidence of their conceptions when compared to the BAU case. While not drastic, the initial difference may be explained by revisiting that fact that the STEMP participants were registered for a female-centered STEM event by their parents while the BAU participants were not, indicating the parents and the home figured world of the STEMP case may prioritize STEM knowledge and experiences more than the BAU case.

The STEMP case experienced transformations in their conceptions of STEM and the STEM community that the BAU case did not. The most prominent changes were in the details the STEMP case provided in their descriptions of STEM and how people in the STEM community engaged in and used STEM in their careers. Participating in the
STEM Princess figured world granted the girls in the STEMP case access to a space for self-authoring through their interactions with role models, dialogue, and practicing STEM. Building rich conceptions related to STEM and the STEM community is the first step toward STEM identities in practice. The participants in the STEMP case completed this process multiple times over the course of the study in addition to their STEM engagement in other figured worlds, allowing them to build richer, more complex conceptions of STEM and the STEM community. In contrast, the participants in the BAU case participated in STEM through their other figured worlds. However, engaging in the STEM Princess influenced the STEMP case’s conceptions to a much greater degree than the BAU case experienced. The frequency of engagement in STEM activities the STEMP case experienced coupled with how the STEM Princess situated the girls built an empowering environment strongly influencing their conceptions of STEM and the STEM community.

**How are STEM sense of belonging and self-efficacy of girls ages five to eight years influenced by engaging in all-female STEM experiences compared to peers who do not engage in the same or similar experiences?**

The sense of belonging and self-efficacy of girls in both cases started and remained intertwined with their conceptions of STEM throughout the study. More specifically, if a participant expressed a change in their conceptions of STEM or the STEM community, a change in their sense of belonging and self-efficacy followed. Conversely, if the conceptions of STEM or the STEM community remained stagnant for a participant, their sense of belonging and self-efficacy remained relatively steady. The
close relationship between conceptions with sense of belonging and self-efficacy aligned with the figured worlds framework. Changes in a sense of belonging and self-efficacy were resultant of having access to figured worlds where the children were situated as participants and given space for self-authoring related to conceptions.

Central to developing a sense of belonging is relating personal identities to the environment and culture in which you are participating, STEM in this case. This includes people, objects, places, and activities. Access to and relations with in-group role models are particularly important for building a sense of belonging. If the participants have a sense of belonging in STEM, they would be more likely to engage in conversation with STEM community members and express comfort in their interactions with people in STEM.

The participants in the STEMP and BAU cases began the study with similarities in their sense of belonging in STEM. Children in both cases identified the majority of images related to STEM as for both sexes. Four images related to robots, construction, and tools were consistently associated with boys. However, none of the images were consistently identified as for girls by either the STEMP or BAU case. The ratio of their selections provided a different picture of STEM than their drawings and selections of STEM persons. While these pieces of data indicated a feminine conception of STEM, their identification of images indicated a masculine conception of STEM. One potential explanation for this is returning to in-group preferences from the girls’ selections of photos with people. However, in-group preferences would not be present with inanimate
objects and places, meaning the sense that STEM is for boys may be a more accurate measure of their sense of belonging in STEM.

The female dominance present in the drawings and PASPT selections of both cases are strong indicators participants made connections between STEM and their own identities as a girl, central to building up their sense of belonging. In contrast, conveying a perception that objects and places salient to STEM were masculine-leaning inhibited their sense of belonging and willingness to engage in STEM. This raised questions about whether or not the girls felt like they belonged in STEM. Returning again to the figured worlds framework, if the figured worlds in which children participate communicated conflicting messages about who belongs in STEM, this could explain the confusion and disconnection between these data sources. It also raised additional questions about what would happen when a new figured world was introduced to the STAMP case.

Few changes in the connection between the STEM-related images and sex occurred within the BAU case one week after our initial interview. Indeed, their connections to which images were for boys, girls, or both remained constant with the exception of one image of a lab coat and glasses switch from for boys to both. The BAU case, without any major changes to their figured worlds, also did not exhibit any changes to their sense of belonging in STEM.

By the second interview, the STAMP case attended the STEM Princess Ball gaining a chance to engage in STEM compared to the BAU case. I anticipated participants would identify more objects for females as a result. However, this did not prove to be true. None of the photos were identified for girls just as was the case in their
first interviews. Further, four images were consistently identified for boys and 12 for both. I did not anticipate a major change after just one exposure to the STEM Princess figured world, but expected the female-centered figured world would provide a counter narrative resulting in a more equitable association between STEM and sex. The lack of change was an indicator of a stagnant sense of belonging for the girls in the STEMP case. Although there was a notable change in their conceptions of STEM and the STEM community after the STEM Princess Ball, this did not translate into a shift in their sense of belonging.

The STEMP case exhibited a change in their association between STEM and sex after engaging in the STEM Princess figured world for nearly 20 weeks. However, by the end of the study, the BAU case exhibited a nearly identical change. Table 6 provides the ratios of how the STEMP and BAU cases connected objects and place related STEM to boys, girls, or both. The ratios emphasized the shift in the STEMP case’s selections that was also present in the BAU case. Both cases identified around 90% of objects and places related to STEM for both boys and girls. While robots transitioned from an object for boys into one for both boys and girls, photos depicting construction and tools remained connected to males. Both cases noted this was because they simply did not see girls at construction sites, and the boys in their families used the tools. This was an important point because construction and the use of tools was also not featured in any of the STEM Princess experiences. The changes in the selections by all participants indicated an emerging gender-neutral perception of STEM, which was associated with a greater sense of belonging in both cases, with the exception of construction and building.
Table 6. Comparing the ratios of selections based on image characteristics of the STEMP and BAU cases.

<table>
<thead>
<tr>
<th>Ratio of STEM Images to Sex</th>
<th>Case</th>
<th>Stage 1 Average (Initial)</th>
<th>Stage 2 Average (After STEM Princess Ball)</th>
<th>Stage 3 Final Average (Study End)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys:Girls:Both</td>
<td>STEMP Case</td>
<td>4:0:12</td>
<td>4:0:12</td>
<td>1:0:15</td>
</tr>
<tr>
<td></td>
<td>BAU Case</td>
<td>4:0:12</td>
<td>3:0:13</td>
<td>2:0:14</td>
</tr>
</tbody>
</table>

NOTE: the final averages were calculated using the full battery of 32 STEM objects and places. For the ease of comparing the stages of the study, the stage 3 ratios were divided into half and represented out of 16 like stages 1 and 2.

The progression of sense of belonging in STEM from girls in both cases was perhaps most evident in their willingness and attitudes toward engaging with people in the STEM community. Both cases started the study wary about engaging with people in the STEM community. Girls expressed feeling nervous and shy around people who work in STEM. In particular, girls were unsure if people who worked in STEM were even safe to talk to, a strong indicator of not feeling like they belonged in the STEM community themselves. Further, the girls struggled to decide what questions they may ask or what topics they may want to discuss. Their feeble conceptions of STEM coupled with an unstable sense of belonging were feeding off of each other and inhibiting their readiness to talk to someone in STEM at the beginning of the study.

The first evidence of a split between the sense of belonging expressed by both cases occurred after the STEMP case engaged in the STEM Princess figured world for the first time at the STEM Princess Ball. The girls in the STEMP case shared their
excitement for talking to people in STEM and produced a series of questions that were specific to the silos of STEM and STEM in and of itself. Many of their questions and topics of conversation related to the activities at the STEM Princess Ball and the new role models with whom they interacted. The personal connections made during their participation in the STEM Princess granted children in the STEMP case access to a space where they could practice dialogue and cultural norms related to STEM. The result was an increase in their sense of belonging that was not present for the BAU case. The girls in the BAU case continued questioning if people in STEM were friendly or even nice. They only wanted to talk to people in STEM if they knew them, but few role models in STEM were mentioned. As a result, the STEM Princess figured world planted a seed for the STEMP case to grow their sense of belonging while the BAU case remained stagnant.

There was an important connection between the increase in sense of belonging expressed by the STEMP case when discussing their willingness to engage with the STEM community and their lack of change with identifying objects and places related to STEM. The STEM Princess Ball experience was focused on physics and flight. Items related to construction and tools were not present, which would not have given girls in the STEMP case an opportunity to change their conceptions of STEM to include these items or disrupt their connections between these items and boys. However, girls engaged with a plethora of females in other STEM fields. This explained the STEMP girls’ increase in their sense of belonging with the exception of construction.

The differences between the sense of belonging of the two cases continued to widen throughout the study. The STEMP case increasingly expressed a sense of
belonging in STEM. One of the strongest influences in their sense of belonging was making connections between STEM with a variety of activities and people already in their lives. Connections were often sparked by STEM Princess experiences or the role models from those experiences. The design of the STEM Princess figured world did make the people and subjects approachable and accessible to participants, which translated into a deeper sense of belonging. Girls in the STEMP case stated they thought they were like the people in the videos and at the STEM Princess Ball because they liked STEM and did the same activities. Eden and Carrie pointed out they were not like all of the adults because they were not princesses, but they were just like the STEM Princess role models. The STEMP girls expressed enthusiasm for the videos featuring role models in medicine, engineering, and mathematics. Overall, the STEMP case had a universally slow but steady increase in their sense of belonging.

The sense of belonging from the BAU case was not as uniform as the STEMP case. On one hand, two of the six members of the BAU case expressed little change in their sense of belonging. Emily and Ingrid were willing to talk to people they knew in STEM, namely their parents, but continued to be wary of others. Furthermore, they had few questions beyond those which they had already discussed with the people the girls were comfortable with due existing relationships. While their conceptions of STEM expanded to include new people, their sense of belonging grew very little. On the other hand, four of the six members of the BAU case engaged with STEM through an existing figured world. Bailey, Ginny, and Penny had STEM experiences at school that helped build their sense of belonging. Each of them finished the study willing and comfortable
talking to people in STEM. However, their growing sense of belonging was not as
striking as the change Remi expressed. Remi’s sudden willingness to engage in
conversation with the STEM community and increased understanding of what the STEM
community included was the most significant change for the BAU case. She went from
little to no sense of belonging to excitement related to engaging with people in STEM.
Remi’s sudden change in her comfort with the STEM community came after talking with
her grandmother about STEM and indicates her interactions with her grandmother
increased her sense of belonging.

The differences in sense of belonging present in the BAU case compared to the
uniformity of the STEMP case makes clear the importance of access in order to develop
identities. The girls in the STEMP case had continuous participation in a figured world
which initiated the cycle of identities in practice. The outcome was an increased sense of
belonging for all of the girls in the STEMP case. When there was access to STEM in
multiple figured worlds, their sense of belonging grew exponentially. For example,
Harper, who engaged in a STEM unit at school at the same time of the study, expressed a
deep sense of belonging and comfort with STEM. Similarly, the girls in the BAU case
who engaged in STEM in other figured worlds also expressed a deeper sense of
belonging. The differences between the STEMP and BAU cases appear to highlight the
influence the STEM Princess figured world had on the girls in the STEMP case. It is
significant to note other figured worlds where STEM was present had similar influence
on participants’ sense of belonging. However, the STEM Princess figured world seemed
to have had a more effective influence on the STEMP participants’ sense of belonging.
A similar evolution occurred in between the STEMP and BAU cases with their self-efficacy. The initial self-efficacy expressed by participants from both cases was weak. Their self-efficacy was shaped across the figured worlds in which they engaged in STEM. However, the only place girls connected to STEM was school. Their success and “positive feedback at school” (Reagan Interview 1, October 1, 2018) were the only influence girls from both cases mentioned in reference to their STEM self-efficacy. Like the divides that occur in the schedule of their school day, participants separated STEM into science, technology, engineering, and mathematics to decide if they were good at STEM, but the girls had largely “never tried STEM” (Remi Interview 1, November 1, 2018). With little experience with STEM, none of the girls from either case expressed a strong STEM self-efficacy at the beginning of the study.

Few girls were interested in STEM-related careers, a further indication both cases had limited self-efficacy. Most girls were interested in careers shared by family members, which seemed to create a sense of belonging in those fields and developing vicarious self-efficacy. Harper and Emily, for example, wanted to stay at home with children like their mothers. Teachers were as important in career selection. Ingrid, Eden, Penny, Remi, and Reagan all stated they wanted to be teachers. Their choice of education was out of a love for the current teacher and feeling successful school. This further emphasized the importance of school in building their self-efficacy. However, in this case, it was not directly related to STEM.

Carrie and Rose, both from the STEMP case, were the only participants that selected STEM-related careers at the beginning of the study. Carrie wanted to be an
astronaut because she liked the idea of going to Mars. Rose wanted to be a vet or create Paw Patrol toys because she loved the dogs in the show Paw Patrol. However, neither Carrie nor Rose thought their career choices were related to STEM. They said they were good at exploring, building, and creating, but these were not skills related back to how they were conceiving of STEM. As a consequence, their career choices did not provide evidence of a STEM self-efficacy that was any greater than the other participants in the STEMP or BAU cases.

The first gaps in self-efficacy from the STEMP and BAU cases occurred after the STEMP case experienced the STEM Princess figured world for the first time. During the second interview, the STEMP case expressed a stronger STEM self-efficacy. Because of their experiences at the STEM Princess Ball, Eden, like the other girls in the STEMP case thought “I am good at STEM” (Eden Interview 2, October 6, 2018). Access to a space where they could practice the skills and knowledge related to STEM and interact with members of the STEM community helped them make connections between their abilities and increase their confidence, two important components of building self-efficacy.

The boost in the self-efficacy of the STEMP case was also evident in their career selections. One of the most important factors for building self-efficacy in the participants of the STEMP case was their relationships with their group leaders who served as role models at the STEM Princess Ball. Reagan, Eden, Harper, and Hannah all expressed new interest in STEM careers based on conversations and interactions with their group leaders. The girls’ conversations with their group leaders shaped their knowledge of STEM careers and broadened which careers they were interested in or reiterated the
connections between the career of choice and STEM. For example, Harper and Eden were suddenly interested in the medical field, an interest of their group leader. Further, they expressed they could be good in medical careers or other STEM careers because they were successful in completing the activities during the STEM Princess Ball. Making connections between their experiences at the STEM Princess Ball and STEM as a whole increased the self-efficacy of the STEMP participants.

The girls in the STEMP case expressed steady increases in their STEM self-efficacy over the course of the study. Persistent engagement in STEM and with the STEM community helped the girls build connections between themselves and STEM careers assuring them they could be successful in those careers. Participants understanding of the careers that developed as they engaged in the STEM Princess figured world helped them build a greater sense of self-efficacy as they expressed feelings of competence and enjoyment. The confidence and competence the STEMP case expressed is relative to broader increase in self-efficacy expressed by the girls over the course of the study.

Participating in the STEM Princess figured world helped the girls in the STEMP case recognize the skills and interests they already related to STEM and why they would be good at STEM careers. This resulted a richer self-efficacy in STEM and the selection of STEM careers by more participants in the STEMP case. For example, Eden now wanted to be “a doctor because” one of the STEM Princess role models she watched “[helped] me learn and they teach other kids” (Eden Interview 6, January 9, 2019). As a whole, the STEMP case was more interested in engaging in STEM, talking with STEM
people, and pursuing STEM careers. This is a significant evolution in self-efficacy over time.

The most significant growth in STEM self-efficacy occurred when the STEMP case participants engaged in STEM across multiple figured worlds. Participating in STEM at school, home, and STEM Princess was a significant influence on self-efficacy development that was not matched by participating in just one of these figured worlds. When other figured worlds aligned with the STEMP case’s experiences in the STEM Princess figured world, the self-efficacy and connections to STEM careers grew exponentially. In one example, Harper completed an engineering at school and another with the STEM Princess which made her feel good at STEM and consider engineering as a career choice. Carrie, for another example, said she was good at STEM “because I do a lot of stuff [at home and school]” (Carrie Interview 3, November 14, 2018). Children in the STEMP case and BAU case who only engaged in STEM in one figured world did not experience the same level of growth as those in the STEMP case who had the opportunity to participate in STEM across figured worlds.

In contrast to the STEMP case, all but one child in the BAU case said they had not done any STEM activities since the first interview. Because their experiences with STEM were not expanded, their self-efficacy and career choices remained the same. The girls in the BAU case were not sure if they were good at STEM and which careers they may want to pursue. Teaching and careers that aligned to their parents persisted as their top choices, but none of the girls in the BAU case selected a STEM career. Unlike the dramatic shift in the STEMP case, the self-efficacy of the BAU case was static.
The girls in the BAU case did not have access to STEM in more than one figured world. In fact, two children, Emily and Ingrid, did not have access to STEM in any of their figured worlds. Like the beginning of the study, their STEM self-efficacy remained focused on their science, technology, and mathematics classroom performance and did not extend into doing STEM more broadly. Ingrid and Emily continued to question if they were good at STEM and were confused about what that may look like. Their STEM self-efficacy at the end of the study was no stronger than it was at the beginning.

The other four girls in the BAU case had access to STEM through one of their other figured worlds: Bailey, Ginny, and Penny at school, and Remi at home. The girls who were in classrooms with STEM lessons expressed more STEM self-efficacy when compared to Ingrid and Emily. Bailey, Ginny, and Penny were able to connect their school lessons to being good at STEM outside of school describing different ways STEM could be used to create new inventions and build various objects. Similarly, Remi started to understand what it looked like to do STEM and make connections to her daily activities. She expressed an increasing self-efficacy when she realized she like to do math and work hard like people in the STEM community.

Engaging in STEM in any context translated into increased self-efficacy but not necessarily to their career choices. On one hand, Penny wanted to talk to someone in STEM about getting a job because she was so profoundly influenced by her STEM experiences at school. On the other hand, neither Ginny nor Bailey had any interest in pursuing a STEM career after participating STEM activities at school. The girls in the BAU case continued to make career choices based on their role models. It is significant to
note the girls in the BAU case did not have access to new role models even if they experienced STEM in one of their figured worlds. For example, STEM at school was facilitated by their existing teacher. In contrast, the STEMP case was exposed to a plethora of new role models and STEM careers through their participation in the STEM Princess figured world. Their role models were central in helping children develop their STEM self-efficacy and sense of belonging.

The discrepancies between STEMP and BAU cases’ sense of belonging and self-efficacy at the end of the study highlighted the influence the STEM Princess figured world had on the girls in the STEMP case. It is significant to note other figured worlds where STEM was present had similar influence on participants’ sense of belonging and self-efficacy. However, the STEM Princess figured world seemed to have had a more effective influence with references to salient role models and feminine activities. A collective increase in self-efficacy coupled with a new sense of belonging are indications of overall STEM identity development in the STEMP case that was not present in the BAU case. Access and participation in rich, welcoming STEM experiences were related to outcomes central to identity development in STEM. Furthermore, increases in sense of belonging and self-efficacy were related to girls’ interest in STEM and willingness to further pursue of STEM.

How does engaging in all-female STEM experiences influence the interests of participants compared to peers who do not engage in the same or similar experiences?
Interests in STEM varied at the beginning of the study: between and across cases. Girls in both cases were predominantly interested in stereotypically feminine toys such as dolls, Barbies, and crafts. Significantly, only Legos were mentioned as an interesting toy related to STEM. Although girls mentioned technology, they were not referencing engaging in STEM-related play. Instead, they used technology for watching shows or playing games like dressing up mermaids or applying makeup to avatars. Girls said they liked STEM when I specifically probed them. Like their self-efficacy and sense of belonging, their STEM interests were associated with school activities, including computer and mathematics games. STEM was not at the forefront of any of the girls’ interests. Their interests were more closely aligned with the items on their gift wish lists: American Girl Dolls, Barbies, and small trinkets like Squishies and LOL Dolls. While the girls may have been willing to engage in STEM, a genuine interest in STEM was not expressed by the participants from either case.

After attending the STEM Princess Ball, girls in the STEMP case shared a new excitement and interest tied to STEM closely connected to the activities from the event. Girls in the STEMP case were eager to continue playing with their Lego balloon cars and excited about how far their test tube rockets travelled. The event was also catalyst for girls in the STEMP case to establish connections between some of their existing interests and STEM. Rose, for example, paired her interest in Paw Patrol characters to veterinarian careers, and building new Paw Patrol toys to inventing. The fun and excitement of the event trickled over into other interests sparking Rose and the other STEMP participants to mention new interests such as experimenting.
Remi, Penny, and Ginny in the BAU case attempted to make similar connections between their interests and STEM. However, STEM was only discussed by the BAU case as an interest when I specifically asked if they liked STEM. My probing may have skewed the responses of the BAU case indicating to participants that I wanted them to talk about interests in STEM. Regardless of the source of their connections between interests and STEM, they were distorted by their persistent misconceptions of STEM. For example, Remi said she liked STEM because she liked making new words and writings highlighting her confusion about how making and building were associated with STEM versus the creative process of writing stories.

Neither case had notable changes in what they placed on their gift lists or how the preferred to spend their time. However, the new connections present between STEM and existing interests in the STEMP case showed growth that the BAU case did not. The difference was in how changes in their conceptions of STEM shaped their understanding of how their interests were associated with STEM. Girls in the BAU case stated they enjoyed playing with Legos and liked design, but these activities did not fit into their conceptions of STEM. By contrast, the expanded conceptions of STEM from the STEMP case helped them connect Legos with building and creating toys with invention. In the cycle of identities in practice, the STEMP case was reauthoring their existing interests as interests in STEM. Some of the BAU participants were attempting the same task, but were inhibited by their exposure to authentic STEM in their figured worlds.

The girls in the BAU case continued to discuss their interests in STEM throughout the study. Like their sense of belonging and self-efficacy, increases in STEM
interests were associated with their engagement in STEM across their figured worlds. Some girls mentioned their attraction to technology and engineering after completing STEM projects in school. Another child mentioned a new interest in animals after her family purchased a new puppy. STEM-rich experiences like these were influential in shaping their interest. The changes in STEM interests within the BAU case closely aligned to their experience and did not seem to weave into other parts of their lives or influence their interests overall. Though they mentioned other STEM items such as Legos, their predominant interests remained with dolls and other stereotypical girl toys such as beauty products and clothing.

Discussing interest in STEM was more organic with the STEMP case. When asked about their interests, the girls in the STEMP case brought up experimenting, building, and technology without additional probing. Many of their interests were directly related to the at-home STEM Princess experiences, such as engineering bubble blowers. They consistently talked about what they did, and why they liked the activities. All of them were sad when the study came to an end because they knew the STEM Princess experiences were also coming to an end. Several begged for more STEM Princess experiences, and others mentioned they added STEM-related kits to their gift lists. Their interests in the STEM Princess experiences spread into STEM more broadly, dramatically altering the gift lists of the STEMP case as a whole. Girls mentioned asking for computers, science kits, and books related to STEM. Interests in STEM beyond the STEM Princess activities is an indication of a growing interest in the field as a whole.
Overall, the STEMP case expressed interests in STEM at the completion of the study that the BAU case did not. The transformation of the gift lists unique to the STEMP participants was one of several indications these girls wanted to further opportunities to engage in STEM experiences. The same was not present with the BAU case. Here it is important to point out it this does not mean the BAU case would not want to engage in STEM. The absence simply means they may not be aware of the potential opportunities that may exist for them to engage in STEM at home and in other spaces. Ultimately, the BAU case did not show the same level of interest in STEM as the STEMP case by the end of the study.

An expression of interest is pivotal in identity development because it is a motivator for pursuing additional opportunities for engaging in STEM across figured worlds. When coupled with a sense of belonging and self-efficacy, interest is the driving force for the continuation of identity development. In this case, the STEMP case provided more evidence they were driven by their interests connected to the STEM Princess to pursue STEM across their figured worlds providing further access to spaces for authoring identities related to STEM.

**How are the STEM identities of White girls ages five to eight years influenced by female-centered STEM experiences compared to similar peers without the same experiences?**

Conceptualizing identity development in STEM required capturing the identities in practice that occurred overtime for participants. The data from this study were relative to each phase of identities in practice. The process of forming conceptions and a space for
self-authoring resulted in the outcomes of sense of belonging, self-efficacy, and interest in STEM. The overarching purpose of this study was to examine how the identities of the STEMP case were influenced by their engagement in the STEM Princess figured world overtime when compared to the BAU case.

The cultural and political dynamics of figured worlds situate and empower the participants in those worlds. In this study, the STEM Princess figured world situated and empowered participants by aligning STEM with role models and experiences that matched the existing identities of the young females in both cases. The influence of the STEM Princess accelerated the process of identity building in the STEMP case. Engaging in activities intertwined with existing interests made STEM more interesting and approachable. Access to role models with similar demographic characteristic made STEM careers and engaging in STEM more comfortable. Experience success in STEM over and over again made girls more confident and motivated to continue. By the end of the study, continuous exposure to the STEM Princess figured world resulted in the more rapid and dramatic growth in the STEM identities of the STEMP case participants when compared to their counterparts in the BAU case. Even when comparing participants in the STEMP and BAU cases who did not have STEM experiences in other figured worlds, the participants in the STEMP case still expressed greater development in their STEM identities. Further, STEMP participants who engaged in STEM across figured worlds completed the study with more developed STEM identities than the girls in the BAU case who had similar STEM experiences in other figured worlds. These comparisons continue
to provide evidence of the effectiveness of the STEM Princess figured world for STEM identity development in young girls.

The identities of the participants in this study changed over time based on the figured worlds in which they participated. Participating in figured worlds with role models and positive STEM experiences related to STEM sparked the process of developing an identity connected to STEM. Though this study focused on the influence of the female-centered STEM Princess figured world, other figured worlds such as home and school also influenced participants’ STEM identities. The greatest development in STEM identities occurred when children participated in STEM across multiple figured worlds.

The evolution in the depth and breadth of conceptions of STEM and STEM community coupled with the growth in sense of belonging, self-efficacy, and interest are evidence the STEM case experienced significant growth in their STEM identities over the course of this study. In contrast, the BAU case had incremental changes in their sense of belonging, self-efficacy, and interests in STEM that were founded on weak conceptions of STEM and the STEM community, both peppered with misconceptions. The growth in identity from the STEM case compared to the relatively lack of transformations in identity from the BAU case indicated a significant difference from the beginning to end of this study. The STEM Princess figured world situated and empowered the girls providing a space to self-author and practice their STEM identities.

Holland, Lachicotte, Skinner, and Cain (1998) describe identity development as a process. Identities are always under development, or practice. Their model of figured
worlds is a cyclical one where identities are developed as individuals participate in figured worlds over time (see Figure 73). However, the STEM identities in practice of children in this study provided an additional dimension to the process of identity development. The figured worlds built upon each other and caused tension to prohibit and inhibit the participants’ STEM identities.

Figure 73: Representation of the figured worlds framework based on research from Holland, Lachicotte, Skinner, and Cain (1998).

The growth of their STEM identities occurred in practice just as Holland, Lachicotte, Skinner, and Cain (1998) presented in their framework. Iterative participation and exposure to STEM-focused figured worlds influenced all participants’ sense of belonging, self-efficacy, interests, and conceptions. However, what is not accounted for in the current model is the vertical nature of identities in practice that occurred for the girls in this study as children participated in STEM across figured worlds. When the STEMP case participants’ positionality and participation in STEM across their figured

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worlds aligned, children expressed elevated STEM identities just like ascending a staircase. In contrast, when their participation in figured worlds were misaligned or children did not have opportunities to engage in STEM, participants had stagnant STEM identities like standing still on a step. There was no movement forward or backward in the development of their STEM identities.

The STEM identities in practice of the STEMP case followed a more dynamic path like the one represented in figure 74. The slow and steady growth of their identities was like climbing a spiral ramp. Each experience related to STEM, regardless of figured world, provided an opportunity for growth in their STEM identities. When there was alignment between their existing identities, such as sex, with the people of the figured world in which they were engaging, such as the STEM Princess, the girls were empowered by their participation in the figured world. This empowerment acted like a rocket boost up that part of ramp. While the BAU case also showed progression in their STEM identities, they had fewer opportunities to make connections resulting in slower movement in advancing their STEM identities. The access and opportunity the STEM Princess provided girls in the STEMP case influenced their identities by elevating their sense of belonging, self-efficacy, interests, and creating clarity in their conceptions of STEM.
Figure 74: Updated representation of the figured worlds framework based on research from Holland, Lachicotte, Skinner, and Cain (1998).
Like climbing multiple levels of a ramp, identities developed in practice, over time, through multiple opportunities to participate in the STEM-rich, female-centered figured world. However, the most dynamic growth was expressed when participants developed their identities in practice, over time, through multiple opportunities to participate in multiple STEM-rich figured worlds in addition to the STEM Princess. Continuing with the stair analogy, access to STEM-rich figured worlds added additional levels to the ramp for girls to continue building up their identity development. This is evidence why identities in practice need to consider the layers as well as cyclical nature of identities in practice.
CHAPTER 5: DISCUSSION, LIMITATION, AND IMPLICATIONS

The purpose of this study was to examine the identity development of young White girls related to STEM. In particular, I investigated the influence of a female-centered STEM figured world on their STEM identity development. I captured the process of identity construction by examining their conceptions of sex, conceptions of STEM and the STEM community, sense of belonging in STEM, STEM self-efficacy, and interests. Overall, this study found the STEM Princess figured world influenced the STEM identities of participants by acting as a catalyst in their STEM identity development when compared to the participants that did not have access to the same or a similar figured world. The differences in the cases’ conceptions, sense of belonging, self-efficacy, and interests give insight into the process of STEM identity development in young females.

This study adds to the sparse research specific to STEM identity development. There is a plethora of research on science, technology, engineering, and mathematics identity development. However, few studies have researched identity development related to STEM as an independent field. I used the overlapping elements of identity development research from each of the siloed fields related to STEM. I also relied heavily upon work from psychology related to identity development, self-efficacy, sense of belonging, and building conceptions. This study applied of these phenomena to STEM to make connections between identity development and STEM. As STEM continued to grow as a field, more studies related to identity development would benefit our understanding of building equity and diversity in the field.
Findings from this study indicate continuous access to figured worlds related to STEM shapes the STEM identities in practice of participants. Engaging in STEM within a variety of figured worlds, school, home, and others, encouraged the identity development of all participants. More specifically, purposefully positioning young girls into a female-centered STEM figured world acted as a catalyst for the identity development of participants in the STEMP case. Shaping STEM experiences where female children could engage with members of the STEM community that looked like them increased their access and opportunities to culminating in more complex STEM identities with a deeper sense of belonging, self-efficacy, and interests related to STEM.

**Discussion**

The STEM Princess figured world was created by combining conceptions of gender with conceptions of STEM common to young children. Like many children their age (Ruble & Martin, 1998), the children participating in this study assigned gender identity using visible social and cultural cues. External features such as long hair and eyelashes, dresses, high heels, and fingernail polish were all part of what made someone a girl. Participants connected their gender conceptions to the interests and roles boys and girls assume. Similar to what Fine (2015) and Kaiser, Haller, Schmitz, and Nitsch (2009) found, children made connections between interests and careers with gender. Female and males, according to Harper, Remi, and other girls, had different interests and careers. Girls liked to paint their nails, and work in fancy dresses. Males liked playing with dinosaurs, and worked in construction. There was a distinct gender gap in participants’ descriptions of gender, with males engaging in science, building, and other activities
related to STEM and no mention of STEM interaction with females, a reflection of the
gendered stereotypes consistent in other research (Hull & Greeno, 2006) related to
conceptions of STEM.

Clear and accurate conceptions of STEM are pivotal for developing a STEM
identity (Hobbs et. al, 2017). The findings of this study indicate talking about and
engaging in STEM with girls from an early age does help build conceptions of STEM,
sparking their STEM identity development. Research on children’s conceptions of STEM
and the STEM community is sparse. There are studies on conceptions related to science
(Chambers, 1983), technology (Martin, 2004), engineering (Knight & Cunningham,
2004), and mathematics (Picker & Berry, 2000), but few specifically on STEM. Even
fewer studies focused on the conceptions of STEM held by elementary children (e.g.
Capobianco, Diefes-Dux, Mena & Weller, 2011), even though children ages five to eight
are at a pivotal period for building conceptual understandings of how gender is an
important part and influence on their identities (Glenn, 1999). Participating in the female-
centered STEM Princess figured world was a powerful influence on girls’ conceptions of
the STEM community. All of the children began the study with few conceptions of
STEM with most unsure of what STEM was. The girls in the STEMP case provided
detailed explanations of STEM and the STEM community by the completion of the
study. Using the role models from the STEM Princess was the most common way
participants explained the conceptions they held of STEM and the STEM community.

One way the STEM Princess figured world situated and empowered young girls
was by making same sex role models accessible, which proved a particularly powerful
influence on their conceptions of the STEM community as well as their sense of belonging and self-efficacy. Figured worlds help position participants through the interactions with and access to people who become salient role models and key figures for forming conceptions and identity development (Ong, Wright, Espinosa & Orfield, 2011; Weber 2011). Studies of females in middle school and beyond indicate having role models and peers with similar demographics is a powerful force for persistence in STEM pursuits (e.g. Espinosa, 2011; Holmegaard, Madsen & Ulriksen, 2014; Wilson, Holmes, Sylvain, et al., 2012). The findings from this study also indicate access to in-group role models and peers were pivotal in the developing a sense of belonging and self-efficacy based on career choices. Other studies of females in STEM support this finding (Drury, Siy & Cheryan, 2011; Trenor, Yu, Waight, Zerda & Sha, 2008).

The girls in this study began forming conceptions of the STEM community at an earlier age than other studies have found. Maltese and Tai (2011) reported most children lose interest in STEM during middle school. These findings coupled with the findings from similar studies matching STEM with identity development (e.g. PCAST, 2010; Wyss, Heulskamp & Siebert, 2012) are why many STEM programs target adolescents. However, this may be too late. Even during elementary school, children perceive STEM as complex and difficult (Christensen, Knezek & Tyler-Wood, 2014). The conceptions of STEM held by the BAU case support these findings. They portrayed STEM as challenging and difficult. Like DeJarnette (2012) suggests, engaging children in STEM much before adolescence proved pivotal in the transformation of the conceptions girls held of STEM. None of the girls in the BAU or STEMP case depicted STEM as difficult
or elitist after participating in STEM within any of their figured worlds. Instead, the findings of this study indicate participating in STEM deepened the girls’ connections to STEM, making it more approachable and increasing their interests in STEM.

Early childhood is a crucial time for opening the door to opportunities that broaden children’s interests by increasing their exposure to experiences, content, and role models (Carter & Welner, 2013). However, previous research related conceptions of STEM and the STEM community found children do not have gendered conceptions until second grade or later (e.g. Chambers, 1983; Knight & Cunningham, 2004). The findings from this study contradict those studies. The drawings and discussions indicate these children do have established conceptions of the STEM community including a conception of the STEM community as gender diverse. Like the Draw a Scientist Test (Chambers, 1983) and the Draw an Engineer Test (Knight & Cunningham, 2004), children’s conceptions of STEM included stereotypical, almost cartoonish, imagery common in media to connect the person to their roles and careers, such as depicting a person in a lab coat using a hammer and nail to repair a car. However, their conceptions did not follow the male-dominated nature of other Draw a “Something” assessments (Chambers, 1983; Knight & Cunningham, 2004; Picker & Berry, 2000). The drawings from participants in both cases were closely connected to their role models, even when the role model’s connection to STEM was vague or a stretch for the child to explain. Similarly, all participants selected more females than males on the PASPT, validating the conception of STEM as female not male, and as a result, increasing their sense of belonging.
Children’s drawings and selections on the PASPT may not accurately depict their conceptions of the STEM community. Preference of in-group people, females in this case, is one alternative explanation for the increase number of females selected on the PASPT (Hilliard & Liben, 2010; Yee & Brown, 1994). The drawings from both cases and images they selected on the PASPT, both featuring people, highlighted children’s conceptions of the STEM community as female. However, the participants’ selections of objects related to STEM may provide a different understanding of their conceptions of STEM with gender as in-group preference does not apply to objects. How participants in both cases gendered the objects and locations related to STEM were different, supporting the theory that in-group preference may have influenced their drawings and PASPT selections. The photos of objects and places related to STEM are significant because they provide clues about the socially and politically dominant groups, indicating who does and does not belong in STEM (Master, Cheryan & Meltzoff, 2016). When children in both cases were not connecting STEM with objects and places, their conceptions of STEM were slightly masculine, but relatively gender neutral. This indicated engaging in STEM in a variety of environments helps build an equitable conception of the STEM community.

Findings from this study support the results from Muzzatti and Agnoli (2007) finding misconceptions about the STEM community can be corrected through interactions with a diverse body of role models and increase girls’ interest in and identification with STEM as a result (NAPE, 2009). The findings from this study and others (Blanchard & Riegle-Crumb, 2017; Roberts, 2014) conclude the efforts to improve
females’ representation in STEM are working. After two decades of STEM-related efforts to attract females to STEM, young girls through young adults are increasingly interested and motivated in STEM. This is significant because interest in STEM is the first step toward the ultimate goal of girls persisting into STEM fields. However, the findings are not all consistent with one another and increased interest is not universal to all STEM fields (Wang & Degol, 2017). Katz (2010) notes one way to close the gender gap in STEM and encourage more children to enter into STEM careers is starting STEM curriculum in early childhood. The findings of this study also indicate engaging children in STEM starting at a young age and continuing into adulthood may be a productive strategy for diversifying the STEM field.

The STEM field is beginning to research and address the systemic biases contributing to persistent underrepresentation of females in STEM fields. This and other studies (e.g. Archer et al., 2013; Carlone, Scott & Lowder; Chacon & Soto-Johnson, 2003; DeWitt & Archer, 2015) found providing a female-centered counter-narrative transforms conceptions of STEM and helps build STEM identities in females. Findings from this study suggest girls are hearing the counter-narrative that anyone can do STEM. However, there are still competing narratives about STEM as masculine-leaning that impact their sense of belonging. The female-centered STEM Princess figured world was a powerful counter-narrative influencing the STEMP case participants’ conceptions of the STEM community, sense of belonging, and overall STEM identities.

Studies of adolescent females (Carlone, Scott & Loweder, 2014), high school females (e.g. Hughes, Nzekwe & Molyneaux, 2013), and females in post-secondary
education (e.g. Perez, Cromley & Kaplan, 2014; Wang, 2013) all conclude situating and empowering females in STEM results in increases in their identification with STEM. Many studies continue to focus efforts to retain females in STEM at the middle level (PCAST, 2010). This study, like Master, Cheryan, Moscatelli, and Meltzoff (2017), found girls start developing STEM identities at a much earlier age which may be an effect of the gender opportunity gap in STEM starting in early childhood. Addressing the gender gap related to STEM in middle school may be too late. Flores (2007) argued the gender gaps in STEM are merely outcomes from the opportunities gap facing females starting at an early age. Participants in both cases of this study support Flores’ argument. None of the girls regularly engaged in STEM activities or STEM conversations at the beginning of the study. Participating in STEM activities and conversations at school and through the STEM Princess figured world provided girls opportunities to make connections and develop their self-efficacy. Closing the opportunity gap for the females in this study gave them access to a sense of belonging and the chance to investigate new interests related to STEM. This was particularly true for the STEMP case as their engagement in STEM was exponentially greater than the BAU case. Studies (Afterschool Alliance Report, 2011; Bell, Lewenstein, Shouse, & Feder, 2009; Yilmaz, Ren, Custer, & Coleman, 2010) have shown that students who have an increased interest in science, mathematics, and engineering early are more likely to pursue a STEM-related career. Access to and opportunities with STEM from an early age could be the catalyst for long-term pursuits in STEM. Master, Cheryan, Moscatelli, and Meltzoff (2017) found access and opportunities to engage in STEM are the most important part of STEM identity development. This
study fully supports this. All participants in this study expressed development of their STEM identities to some degree. The girls in the STEMP case referenced experiences at home and school in conjunction with the STEM Princess at-home experiences as influences on their STEM identities. The BAU case also experienced growth in their STEM identities, largely influenced by our interviews during the study and school experiences. The identity development of the BAU case was more superficial and did not transfer to personal interest or long-term vision of self.

Other studies (Nugent, Barker, Grandgenett, & Welch, 2016; Yilmaz, Ren, Custer, & Coleman, 2010) comparing female engagement in formal versus informal STEM learning environments had similar findings about increases in STEM interests and future plans related to STEM. The formal learning environment was not enough exposure to STEM or role models related to STEM to spark the development of STEM identities in the same way the STEM Princess did. This study found access to experiences across figured worlds, positioning, and experiencing success are the keys to developing STEM identities. STEMP case experienced more dynamic and greater development in conceptions of STEM, gender inclusion, self-efficacy, sense of belonging, and interest as a result of their access to a variety of opportunities related to STEM.

As a concluding point of discussion, this study revealed a connection missing between the home and other figured worlds emphasizing STEM. As stated in chapter 3, I attempted to collect several points of data dependent on parent participation, namely videos of the parents and children participating in the STEM Princess at-home experiences. These videos were not usable data because parents did not do it or, more
frequently, only selective parts of the experiences were recorded. I discussed the fear of recording with parents. Several mentioned feeling inadequate in their knowledge and abilities related to STEM. Other studies (Goodwin, Cooper, McCormick, Patton & Whitehair, 2014; Nugent, Barker, Welch, Grandgenett, Wu & Nelson, 2015) support this finding noting parents often limit STEM-related activities due to their own insecurities. Although parents did not want to record their participation in the STEM Princess activities, they mentioned how much easier it was to facilitate with the complete kit and instructions available to them. Parents particularly liked the videos in the at-home experiences because helped them explain the experience to their child which resulted in less anxiety for the parents. Purposefully designing opportunities for partnering with parents is another way children’s figured worlds can promote STEM identity development (Breiner, Harkness, Johnson & Koehler, 2012).

**Limitations**

A limitation of this study is the sample. Participants were a racially homogeneous group that also shared socioeconomic status, family dynamics, and geographic location. Though the homogeneity of the participants was one method used to tightly bind the cases, I also realize the privileges afforded to the children in the study makes it difficult to generalize the findings of this study to other more diverse populations. Further research of diverse populations is necessary to fully understand STEM identity development in concert with the STEM Princess figured world.

Another limitation of this study was the focus on the influence of female-dominated figured world. It is not clear if presenting the same content and consistent
access to STEM through other figured worlds, such as a male-dominated or gender-neutral figured worlds related to STEM, would have had the same influence on participants’ STEM identity development. Additional research comparing the influence of figured worlds focused on STEM and centered on multiple expressions of gender or other demographic characteristics would add to the body of literature examining how figured worlds influence diverse populations.

A final limitation is time. I studied the identity development of participants over a five-month period. However, identity development is an ongoing process and practice. I am not aware of the duration of the influences the STEM Princess figured world had on participants’ STEM identities after their engagement in the STEM Princess concluded. Further, this study did not provide an understanding of how often or how long individuals need to engage in a particular figured world in order to experience the related influences because I only collected data during a short period of their lives. A study conducted over a longer period of time may provide additional details on how access to a figured world related to STEM influences identities over time. Additional research is necessary to understand how figured worlds influence the STEM identities of females from early childhood to adulthood.

**Implications and Conclusion**

Participating in the STEM Princess figured world gave children access to a space for authoring their STEM identities rich with experiences, dialogue, and female empowerment. Most importantly, the STEM Princess figured world provided the STEMP case an opportunity to interact with new role models in STEM. The connections between
the existing identities of participants and the STEM Princess figured world created a catalyst for identity development, including building their conceptions, sense of belonging, self-efficacy, and interests related to STEM. This study contributes to the field by highlighting the influence a STEM figured world can have on STEM identity development when the participants are empowered and situated by the social and political environment of the figured world. Children’s identity development heavily depends on how important adults situate them into or out of contexts (Valentine, 2000). This is why it is essential for the field to consider the development of figured worlds where individuals can be situated into a STEM environment with adults and experiences where they are empowered. Children’s identities are influenced by their relationships with others and how they are situated within their figured worlds (Carver, Yunger & Perry, 2003). The findings from this study indicate careful consideration of existing interests and identities that can be aligned with STEM content is an effective pathway toward building STEM identities in children. By aligning femininity with princesses and STEM, the children in the STEM Princess case developed their STEM identities through their participation in the STEM Princess figured world.

In this study, participants’ identities were shaped and reshaped by their participation in the STEM Princess figured world as well as other figured worlds, such as school and family. While the STEM case expressed notably greater growth in their STEM identities when compared to the BAU case, a significant findings of this study is the growth in STEM identities of all the participants. This study aligns with those of Worth (2009) by finding the lived experiences of individuals shape and reshape their
identities. In this study, opportunities to gain access to experiences in STEM shaped the STEM identities of participants. This is evidence for the field to collaborate on opportunities to expose children to STEM. There is a need for collaborative, cross-environmental exposure to nurture STEM identities starting at an early age. This is particularly important for traditionally underrepresented groups in STEM, including females.

Evidence of dramatic changes in the identities of the young children in this study adds to previous research focused on targeting adolescents with STEM identity development (e.g. Afterschool Alliance Report, 2011; Chacon & Soto-Johnson, 2003; Muzzatti & Agnoli, 2007). A multi-faceted approach to STEM identity development needs to start earlier and continue through adolescence. All stakeholders who make up the figured worlds children participate in - schools, families, and outside organizations - need to develop programming for young children as well. Informal learning environments that create figured worlds related to STEM, such as camps and afterschool clubs, are a proven mechanism for connecting stakeholders and providing access to STEM. Outcomes of informal learning environments include increasing STEM interests and engagement in the early grades (e.g. Karp & Maloney, 2013) and other ages (e.g. Tan et al., 2014). However, informal learning environments are not enough to build robust STEM identities. Access to STEM must span across children’s figured worlds.

Children spend the majority of their waking hours in school or child care (Hofferth & Sandberg, 2001) making it one of the most important figured worlds for young children. The findings from this study of highly privileged participants underscore
just how few opportunities are available in early childhood related to STEM.
Unfortunately, this limited the participants’ access to STEM. While early childhood
education is beginning to include STEM content (e.g. Katz, 2010; McClure et al., 2017),
more curriculum and content needs to be integrated into the early grades (Chesloff, 2013;
DeJarnette, 2013). The findings from this study point to children’s classroom experiences
and teachers as pivotal influences in their STEM identity development. However, their
exposure was limited and inconsistent. One barrier is early childhood teachers’
knowledge and comfort with STEM content and pedagogy (Breiner, Harkness, Johnson
& Koehler, 2012). Providing professional development for teachers and administrators is
a proven pathway for giving educators the knowledge and resources they need to
integrate STEM into early childhood education (Campbell, Speldewinde, Howitt &
MacDonald, 2018; Jamil, Linder & Stegelin, 2018). Further, integrating STEM pedagogy
and methods into teacher education programs is essential to prepare future teachers for
integrating STEM into their curriculum and increasing children’s access in the early
grades (Haslip & Gullo, 2018; Kim, Kim, Yuan, Hill, Doshi & Thai, 2015). As children’s
access to STEM increases across their figured worlds so too will their opportunities to
develop their STEM identities. Developing rich STEM identities is going to take a
multifaceted effort to provide access to STEM for children.

Finally, the first and most salient figured world of a young child is their home
(Valentine, 2000). Parental involvement and support of education are widely accepted as
critical to children’s academic success (Fan & Chen, 2001). When a child’s funds of
knowledge align across figured worlds, they are more likely to express sense of
belonging, self-efficacy, and interest, and build stronger identities (Esteban-Guitart & Moll, 2014). Unfortunately, parents, like those in this study, often avoid engaging in STEM at home because they are intimidated by content and activities related to STEM (Nugent, Barker, Welch, Grandgenett, Wu & Nelson, 2015). Providing the parents in this study with easy-to-implement STEM experiences increased children’s opportunities to engage in STEM at home. The STEM Princess at-home experiences are one example of one figured world reaching another by providing additional resources to parents, connecting the STEM Princess and home figured worlds. Parents were notably more comfortable facilitating STEM activities when everything was provided: supplies, instructions, probing questions, answers, and videos. Situating children for engagement in STEM across figured worlds also requires positioning parents by supporting their efforts to do so. STEM education advocates need to consider how to support parents and families in their efforts to extend children’s STEM experiences across figured words, especially at home.

In conclusion, the field of STEM needs to more purposely consider how individuals are experiencing STEM to diversify participation. The STEM Princess figured world situated young females into a space where they were empowered by bringing STEM content to them. Tapping into existing interests in princesses made the unfamiliar STEM content more approachable and interesting to the participants. The presentation of STEM experiences by in-group role models helped develop a sense of belonging while success in those activities shaped participants’ self-efficacy and career choices to develop identities related to STEM. The masculine conceptions and
stereotypes commonly related to STEM were eroded into equitable, dynamic conceptions of STEM and the STEM community. The overall identity development of the STEMP participants was positively influenced by the connections the STEM Princess figured world made between their existing identities and additional opportunities to access STEM within other figured worlds. Constructing a female-centered figured world by merging princesses and other popular interests of young girls with STEM role models provided an approach to develop STEM identities.
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APPENDIX A. IRB APPROVAL LETTER

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Date: 9/18/2017
To: Ashley Delaney
3808 SW Franklin Dr.
Ankeny, IA 50023

CC: Dr. Christa Jackson
1688 Lagomarcino
Dr. Cassandra J Darius
4380 Palmer

From: Office for Responsible Research
Title: The STEM Princess: Engagement and Interest of Young Girls in STEM
IRB ID: 17-331

Approval Date: 9/18/2017  Date for Continuing Review: 9/4/2019
Submission Type: New  Review Type: Full Committee

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.

- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.

- Obtain IRB approval prior to implementing any changes to the study by submitting a Modification Form for Non-Exempt Research or Amendment for Personnel Changes form, as necessary.

- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.

- Stop all research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Research activity can resume once IRB approval is reestablished.

- Complete a new continuing review form at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please be aware that IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. Approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. IRB approval in no way implies or guarantees that permission from these other entities will be granted.

Upon completion of the project, please submit a Project Closure Form to the Office for Responsible Research, 202 Kingland, to officially close the project.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.
APPENDIX B. STEM PRINCESS AT-HOME KITS IN ORDER

**Materials:**
- Elastic String
- Beads

**Directions for Completing STEM Experience:**
1. Complete with an adult. This kit includes small parts that may be a choking hazard.
2. Watch instructions video with the Polynesian Princess. (Green QR Code)
3. Gather all materials from the STEM Princess Kit.
4. Immediately after opening the STEM kit, take beads into a dark room and wait 10-15 seconds. What happens?
5. Place the beads in direct sunlight and observe for 5-10 seconds. Ask your child what they are noticing. What happened? Why?
6. Sort beads into piles based on color.
7. Choose a pattern or design for your bracelet. You may choose to have several patterns.
8. Tie one bead on the end of the elastic string.
9. Add the beads to your bracelet and tie the end.
10. Wear your bracelet into a dark room at home and wait 10-15 seconds. What happens? Ask your child why this may be happening.
11. Watch STEM role model video. (Pink QR Code)
12. These monthly experiments are offered free to your child due to research-based grant funding. Please complete the feedback survey by scanning the Black QR code.

**Important Links:**
- Directions Video with Anna (Green QR Code)
  [https://youtu.be/FW3J0d7x76](https://youtu.be/FW3J0d7x76)
- STEM Princess Role Model Video (Pink QR Code)
  [https://youtu.be/Tf96qf0MG](https://youtu.be/Tf96qf0MG)
- Monthly Feedback Survey (Black QR Code)
  [https://goo.gl/forms/Mf3o1g09m25XYdmL](https://goo.gl/forms/Mf3o1g09m25XYdmL)

**What is happening?**
- The ability to find and build patterns helps children (and adults) make predictions in STEM. Understanding patterns helps children in mathematics as patterns are the foundation of many concepts: counting, adding, geometry, and more. The goal with patterns is to see relationships and develop generalizations about what will logically happen next.

- The beads included in the kit are engineered both to glow-in-the-dark and change colors in sunlight. Materials engineer the plastic by mixing it with two compounds prior to being shaped into beads. First, phosphors are added. These compounds radiate visible light after being “energized” by ultraviolet (UV) light. When first placed in the dark room, nothing happens because they have not yet been energized by UV light. However, after sitting in the sun — our greatest source of UV rays — they are energized and glow in the dark the second time in the dark room.

- Second, a pigment sensitive to UV light is added. When the sun hits the beads, the pigment expands exponentially making the previously invisible pigment now visible changing the color of the beads. UV beads are often used as a detector of dangerous forms of light the human eye cannot see. Researchers in Antarctica use these beads to determine when they are most likely to get sunburned as the ozone is thinnest over this part of the world. After making your bracelet, there should be a small number of remaining beads. Try protecting the beads from the sun using sunglasses, a hagie-covered in sun screen, or a pill bottle. All of these items are engineered to block UV rays. Do the beads still change color? Why or why not? (Hint: the chemical reaction does not occur or occurs lesser in the beads.)

**Important Safety Information:**
- Always complete STEM Princess activities with adult supervision.
- Read all directions before beginning a STEM Princess activity. Use all materials as directed.
- Wear your lab gear!
  1. Protect your eyes by wearing your safety glasses at all times.
  2. Wear your lab apron to protect your clothing.
  3. Protect your hands by wearing disposable gloves at all times.
  4. Tie back long hair, and remove any loose/dangling clothing/jewelry.

- All chemicals and materials can be dangerous when mishandled. Use all chemicals and materials ONLY as directed.
- Keep all materials away from your mouth, eyes, nose, ears, and other body openings. Do NOT eat or taste any materials.
- Wash your hands with soap and water after completing the activity.
- Clean up your work area and supplies. All materials provided are safe to dispose of in your normal garbage and to wash with soap and water.
At Home STEM Kit
Engineering the Ice Queen’s Bubbles

Materials:
Included in STEM Princess Kit
3 different wires
Bubble concentrate
Photo sort

Gather from Home
Scissors
3 oz distilled water
Container/cup

Directions for Completing STEM Experience:
1. Watch directions video with the Ice Queen. (Green QR Code.)
2. Pour 3 oz distilled water into a container. Ask your child if they know what distilled water is and/or why it is different than tap water.
3. Cut open the bubble concentrate and pour 1 T into the distilled water. Ask your child what they notice. What does it look like?
4. Mix thoroughly. Ask your child what is different than before. What does it look like now?
5. Let the bubble solution sit for at least an hour. If you let it set for more than 5-6 hours, cover the solution to prevent evaporation.
6. Let your child sort the photos into piles. Ask about how they are sorted. Talk about the included photos of bubble blowers. What do they notice about them? What do they have in common? What parts are essential? Make a list of what they think their blowers need to include. Hypothesize which wire will work best for a blower.
7. Shape the different wires into bubble blowers. Remind kids they are engineering a bubble blower of their choice. Not all of them will look the same.
8. Test each of the bubble blowers to see which one works the best. Ask your child why they think that one works the best. Does the shape matter? Which texture works the best?
9. On a freezing day, blow bubbles outside. Try to catch a bubble on the blower or observe one that lands on a surface. What do you see? What is happening? What happens when you touch it?
10. Watch STEM role model video. (Pink QR Code)
11. These monthly experiments are offered free to your child due to research-based grant funding. Please complete the feedback survey by scanning the Black QR code on the back.

Important Links:
- Directions Video with Anna (Green QR Code)
  https://www.youtube.com/watch?v=ynS6vDpOH_U
- STEM Princess Role Model Video (Pink QR Code)
  https://youtu.be/pdZFeexKvIg
- Monthly Feedback Survey (Black QR Code)
  https://goo.gl/forms/1QYMqS5xkR125m32#

What is happening?
Bubbles form because water has high surface tension. Water is made up of hydrogen and oxygen atoms (H₂O). The hydrogen atoms in one water molecule are attracted to the oxygen atoms in another water molecule. This attraction forms a sort of scientific hug called surface tension. Soap bubbles form when air is trapped inside bubble solution. Just like other bubbles, it is the high surface tension of the water that causes the bubble sphere to form. The dish soap forms a layer of protection between the water and the air preventing the water from escaping, or evaporating. The glycerin adds an extra layer of evaporation protection helping your bubble last longer as they freeze. The bubbles freeze because it is changing from a liquid to a solid: water to ice. If you watch closely, you can see the crystals form as the bubbles freeze into ice. All ice and snow on Earth have a symmetrical hexagonal, or six-sided, pattern.

Adding the concentrate to water creates a solution. It is best to use distilled water because tap water includes minerals that can interfere with the surface tension of water. This means the bubbles are not as strong. When you let your bubble solution rest for a few hours, it helps the bonds connect and forms a super solution. Try adding more or less water to the solution to see what happens.

Important Safety Information:
- Always complete STEM Princess activities with adult supervision.
- Read all directions BEFORE beginning a STEM Princess activity. Use all materials as directed.
- Wear your lab gear:
  1. Protect your eyes by wearing your safety glasses at all times.
  2. Wear your lab apron to protect your clothing.
  3. Protect your hands by wearing disposable gloves at all times.
  4. Tie back long hair, and remove any loose/dangling clothing/jewelry.
- All chemicals and materials can be dangerous when mixed. Use all chemicals and materials ONLY as directed.
- Keep all materials away from your mouth, eyes, nose, ears, and other body openings. DO NOT eat or taste any materials.
- Wash your hands with soap and water after completing the activity.
- Clean up your work area and supplies. All materials provided are safe to dispose of in your normal garbage and to wash with soap and water.
Kaleidoscopes with Aurora

Materials:
- Included in STEM Princess Kit:
  - Kaleidoscope Circle Template
  - Bendy Straw
  - Prism/Rainbow Lens
  - Mirror Paper

- At Home:
  - Scissors and Hole Punch
  - Markers or Crayons
  - 2 Empty Toilet Paper Rolls
  - Tape
  - Ruler or Measuring Tape

Directions for Completing STEM Experience:
1. Watch directions video with Aurora. (Green QR Code)
2. Gather all materials from the STEM Princess Kit and at home.
3. Divide the mirror paper sheets into 1½ inch strips in the “landscape” position. Cut out the strips. Ask: Why do you think it is so important to measure precisely?
4. Tape the edges of 3 strips of mirror paper together on the paper side. Once all edges are taped together, you should have 2 triangles with the mirror side facing in.
5. Color the insides of the circle templates. Encourage your child to divide the circle into halves, fourths, or more. Use patterns and a variety of designs.
6. Cut out the circles. Use a scissors or hole punch to create a small hole in the middle.
7. Measure 4 inches of the straw (be sure to include the bendy part). Cut on the line. Discard the remaining piece.
8. Tape the straw to a toilet paper roll with the bendy part at the edge. Slide one of the circle templates onto the straw and bend it to secure the paper circle.
9. Insert one of the mirror paper triangles into the opposite end of the toilet paper roll. Your first kaleidoscope is complete!
10. To make the second kaleidoscope, tape the prism lens to the end of a toilet paper roll. Careful to not cover any part of the lens.
11. Insert the other mirror paper triangle into the opposite end of the toilet paper roll. Your second kaleidoscope is complete!
12. To use your kaleidoscopes, look into the open end of the roll and tip the other end toward a light source. Spin the circle or the roll.
13. Watch STEM role model video. (Pink QR Code)

Important Links:
- Directions Video with Aurora (Green QR Code)
  - https://youtu.be/6zI1sleeEOg
- STEM Princess Role Model Video (Pink QR Code)
  - https://youtu.be/T9sMGe8BAlE

Please complete the feedback survey. Scan the Black QR code or visit
  - https://forms/g4ps/PxGxAT711sLt2

What is happening?
Kaleidoscopes originate in ancient Greece where they were used as entertainment. When you look through the eye hole, the light passes through the prism lens or colored paper template which illuminates the colors. These colors are reflected over and over again inside the tube by bouncing from mirror to mirror. Your eye sees different patterns and shapes as the objects bounce and reflect of the mirrors.

The prism lens provides an opportunity to talk about the spectrum of colors that make up white light. When you look into the light with the kaleidoscope with the prism lens attached, you see rainbows. This is because the prism lens separates the white light into Red, Orange, Yellow, Green, Blue, Indigo, and Violet. Scientists often use the name ROY G. BIV to remember these colors and their order.

Kaleidoscopes use the reflections of mirrors placed at particular angles, usually a triangle, to create a beautiful image from ordinary objects. Triangles work best because the Law of Reflection states light is reflected, or bounced away, from smooth and shiny surfaces at the same angle. Our triangles have 3 equal angles making it an equilateral triangle. This means the light bounces at equal angles creating a symmetrical pattern. Ask your child about symmetry and try changing the shape of the triangle by using the smaller leftover pieces. When the triangle is not equilateral, is the pattern still symmetrical?

Measurement is often challenging for young children because it requires precision and diligence. Encourage your child to measure twice before cutting. Ask your child how engineers may use precise measurements when they design and build their models.

Important Safety Information:
- Always complete STEM Princess activities with adult supervision, especially while using the scissors and/or hole punch.
- Read all directions BEFORE beginning a STEM Princess activity. Use all materials as directed.
- Keep all materials away from your mouth, eyes, nose, ears, and other body openings. DO NOT eat or taste any materials.
Materials:

- Included in STEM/At-Home Kit
  - 4-5"x5" piece of photosensitive paper
  - 2-4"x6" pieces of white cardboard
  - 4-6 inch long tongue depressors

Gather from Home
- PVA/250 glue stick or similar glue
- 3 cups of water
- Items from nature walk

Directions:

1. Watch video K2 with Rapunzel.
2. Go on a nature walk to gather items for your photosensitive painting. Collect a bag of interesting items to use.
3. In a space with shade or diffused light (i.e., inside), remove photosensitive paper from cardboard.
4. Arrange the items collected on the nature walk on the paper. If items are flat, consider placing a sheet of glass from a picture frame on the top. This will help produce a crisp image.
5. Place plastic paper with arranged items into direct sunlight for 3-5 minutes. If it is a cloudy day, you will need to wait up to 20 minutes for the paper to develop.
6. Remove the items from the paper once the colors begin to develop or change to a lighter color.
7. Return the paper with arranged items to a space with shade or diffused light. Remove items.
8. Submerge photosensitive paper in water for 2-5 minutes.
9. Lay photosensitive paper flat to dry. Fixing paper or the cardboard will help reduce wrinkles.
10. While the photosensitive paper dries, immerse the four tongue depressors and glue the ends to form a square.
11. Watch video K3 with a STEM guide model while the paper and glue both dry.
12. Tape dry photosensitive pieces to the inside of the decorated frame to display.

Important Safety Information:

- Always complete STEM/At-Home activities with adult supervision.
- Read all directions BEFORE beginning a STEM/At-Home activity. Use all materials as directed.
- Wear your lab gear!
  1. Protect your eyes by wearing your safety glasses at all times.
  2. Wear your lab apron to protect your clothing.
  3. Protect your hands by wearing the provided disposable gloves at all times.
  4. Tie back long hair, and remove any loose or dangling clothing and jewelry.
- All chemicals and materials can be dangerous when misused. Use all chemicals and materials ONLY as directed.
- Keep all materials away from your mouth, eyes, nose, ears, and other body openings. DO NOT eat or taste any materials.
- Wash your hands with soap and water after completing the activity.
- Clean up your work area and supplies. All materials provided are safe to dispose of in your normal garbage and to wash with soap and water.

November 2017: Directions for Supervising Adult

1. Adult read the “What is Happening?” and experience directions. This will give you an outline of what you expect while completing this STEM experience with your child. Detailed instructions and a materials list is provided on the back.
2. Scan the QR code to watch a STEM tutorial video about the STEM experience of the month.
3. Complete the experience using the provided materials.
4. Discuss the experience and learn about the child’s thinking using the following prompts:
   a. Why did you select these items to make your photosensitive painting?
   b. What are some changes you see a lot of during the fall/patterns? Why do you think this is?
   c. What happens in the fall?
   d. What do you think is going to happen when we put this paper in the sun?
   e. How did the color change when we dipped it in water? What do you think happened?
   f. What is your favorite part of this activity?
5. Visit the YouTube video to watch the MAGENTA QR code to watch a STEM professional apply the concept from the monthly experience to her career.
6. These monthly experiments are offered free to your child due to research-based grant funding. Please complete the feedback survey by scanning the QR code below or at https://www.engagekiwi.com/feedback.html.

What is happening?

Photosensitive paper includes two crucial molecules that undergo a chemical reaction, forming a new molecule. The paper is coated with Berlin Green, a common photosensitive substance. Berlin Green’s scientific name is Tri-(R)-trans-2-naphthoic acid (H), which is also known as Berlin Green (H)

A chemical reaction is started when ultra-violet rays, sunlight, hits the Berlin Green creating a new substance called free (H) trans-2-naphthoic acid (H), which is also written as RuPc(0,0,0,0). The common name is Pernona Blue. Areas exposed to ultra-violet rays undergo this chemical reaction while those covered by the objects gathered on the nature walk are protected from the exposure of sunlight and do not undergo the same reaction. In other words, parts that have been covered will contain the original Berlin Green while the exposed areas now contain Pernona Blue.

The discovered happens when the paper is “steamed” by the water. However, there are actually two things happening at the same time in a process for one effect. The Berlin Green is water-soluble and washes away as soon as it is placed in the bad. Pernona Blue is not water-soluble, so it remains on the paper even after submerged in water. The water also causes a chemical reaction called oxidation. Water is scientifically written as H2O. Oxidation is when the oxygen molecules in water chemically react with the Pernona Blue turning the colorless compound into a deep blue.
Materials:
- Included in STEM Princess Kit
- 1 small diaper
- 1 zip close plastic bag
- 1 pipette
- 1 bag of salt

- Gather from Home
- Scissors
- 2 cups of water
- Tall glass/clear container
- Wax paper/plastic plate

Directions for Completing STEM Experience:
1. Watch directions video with Anna. (Green QR Code)
2. Gather all materials from the STEM Princess Kit and home.
3. Cut open the diaper (requires adult supervision and assistance) and place in plastic bag.
4. Zip plastic bag close with plenty of air for the diaper to move around. Begin shaking the bag vigorously for 3-5 minutes. Small white granules will start to fall out of the diaper. You may need to ruffle the fibers of the diaper to get as much of the powder out as possible. Ask your child what they are noticing.
5. Dump the white powder from the diaper into the cup or other clear container. Remove any cotton fibers that may also fall into the cup.
6. Use the pipette to slowly add water. Add 10-15 pipettes full of water and observe what happens. Ask your child what they think is happening. After 1 pipette, ask her to hypothesize how many the powder can hold. Slightly shaking the mixture may help it hold more water.
7. Optional: place the resulting gel (looks like ice crystals) on a piece of wax paper or plastic plate to play with it. Ask your child what it feels like. Try comparing it to other familiar substances.
8. Dissolve the salt packet into a small amount of warm water (1-3 tablespoons). Add to the gel and observe what happens. Ask your child why she thinks this may be happening.
9. Watch STEM role model video. (Pink QR Code)
10. These monthly experiments are offered free to your child due to research-based grant funding. Please complete the feedback survey by scanning the Black QR code on the back.

Important Links:
- Directions Video with Anna (Green QR Code)
  https://www.youtube.com/watch?v=rwiS5yD01U4
- STEM Princess Role Model Video (Pink QR Code)
  https://www.youtube.com/watch?v=ce9N6dLoGIc
- Monthly Feedback Survey (Black QR Code)
  https://goo.gl/forms/3PaB2pQp3W-c7JhJ5k

What is happening?
Disposable diapers include a super-absorbent polymer called sodium polyacrylate (C37H36N16O24H16Na). This is the white granular powder that shakes out of the fibers of the diaper as the child shakes the bag. Sodium polyacrylate possesses a positive anionic charge that attracts water (H2O), a polar (or bent) molecule that has a slight negative charge. As your child pipettes water into the cup with a few granules of sodium polyacrylate, it turns into a solid gel that looks like ice crystals. Your child should even be able to tip the cup upside down because the gel will initially stick to the sides of the cup. When the salt (NaCl) is added, it breaks down positive (Na+) and negative (Cl-) ions disrupting the attraction between the sodium polyacrylate and water. This causes the water to "leak" from the polymer and returns the solid gel to a liquid.

Sodium polyacrylate is great for disposable diapers because it absorbs 500 to 1,000 times its mass in water. There are many other industrial and practical uses of sodium polyacrylate. Try using the Internet to search for ways engineers and chemists use sodium polyacrylate. What applications can you and your child imagine? Can you find anything in your home made with sodium polyacrylate?

Important safety information:
- Always complete STEM Princess activities with adult supervision.
- Read all directions BEFORE beginning a STEM Princess activity. Use all materials as directed.
- Wear your lab gear!
  1. Protect your eyes by wearing your safety glasses at all times.
  2. Wear your lab apron to protect your clothing.
  3. Protect your hands by wearing disposable gloves at all times.
  4. Tie back long hair, and remove any loose/dangling clothing/jewelry.
- All chemicals and materials can be dangerous when misused. Use all chemicals and materials ONLY as directed.
- Keep all materials away from your mouth, eyes, nose, ears, and other body openings. DO NOT eat or taste any materials.
- Wash your hands with soap and water after completing the activity.
APPENDIX C. DEMOGRAPHIC SURVEY

1. Child’s first and last name.

2. Child’s birthdate.

3. Child’s sex.


5. Parent #1 education level.

6. Parent #1 occupation and/or degree.

7. Parent #2 education level.

8. Parent #2 occupation and/or degree.

9. How often does your child engage in STEM activities at home?

10. How often does your child engage in STEM activities at school (not including mathematics, science, or technology instruction)?

11. How often does your child engage in STEM activities in other environments?

12. What does your child want to be when she/he grows up?
APPENDIX D. CHILD INTERVIEW PROTOCOL

- What are your favorite things to do and play with? (Interest)
- Do you know what STEM is? (Conceptions of STEM)
- Do you like STEM? Why or why not? (Interest and Conceptions of STEM)
- Tell me about someone who is good at STEM activities. (Conceptions of STEM and Sense of Belonging)
- Would you feel comfortable talking to an adult who works in a STEM job? What would you ask/talk about? (Self-Efficacy, Agency, and Interest and Sense of Belonging)
- Do you think you are good at STEM? Why or why not? (Self-Efficacy and Agency)
- What jobs are you considering for when you grow up? (Interest and Sense of Belonging)
- Would you be interested in a job in STEM? Why or why not? (Interest and Agency)
APPENDIX E. EXTENDED CHILD INTERVIEW PROTOCOL

PART 1: Non-STEM

- Pretend you have a chance to have a whole day doing just what you want to do. Describe to me how you would spend your day. (Interest)
- What are your favorite things to do and play with? (Interest)
- If you could pretend to be anyone: real, imaginary, famous, or friend; who would you pretend to be? Why? (Interest and Self-Efficacy)
- What jobs are you considering for when you grow up? (Interest and Sense of Belonging)

PART 2: STEM

- Do you know what STEM is? (Conceptions of STEM)
- Draw a STEM person. (Conceptions of STEM)
- Do you like STEM? Why or why not? (Interest and Conceptions of STEM)
- Tell me about someone who is good at STEM activities. (Conceptions of STEM and Sense of Belonging)
- Is there anything you want to do more of after doing those kits? (Interest and Agency)
- Do you think you are like the people you saw in the videos? (Sense of Belonging, Self-Efficacy and Agency)
- Would you want to be like the people in the video? (Interest and Sense of Belonging)
- Would you feel comfortable talking to an adult who works in a STEM job? What would you ask/talk about? (Self-Efficacy, Agency, and Sense of Belonging)
  - MODIFIED: Would you feel comfortable talking to an adult who works in a STEM job, if you knew they were a safe person to talk to? What would you ask/talk about? (Self-Efficacy, Agency, and Sense of Belonging)
- Do you think you are good at STEM? Why or why not? (Self-Efficacy and Agency)
- Would you be interested in a job in STEM? (Interest and Agency)
- Tell me about someone who is good at STEM activities. (Sense of Belonging)
- Do you do STEM at home? Tell me about that. (Self-Efficacy and Agency)
APPENDIX F. PARENT INTERVIEW PROTOCOL

• Do you know what STEM is? Describe.

• What does your child like to do or play? Favorite toys/games? (Interest)

• Did you notice any differences in this child’s preferences, play, or participation over the last six weeks? (Interest)

• What careers/roles does your child want to be when she grows up? (Sense of Belonging, Agency, and Interest)

• Has your child connected anything from the STEM Princess Ball or at home experiences to other parts of her life? (Interest, Self-Efficacy, and Agency)

• What is currently on her gift list? (Interest)

• Does your child like STEM? Think she’s good at STEM? (Interest, Self-Efficacy and Agency)

• Does your child engage in STEM activities or conversations? (Agency and Interest)
APPENDIX G. DRAW-A-STEM-PERSON PROTOCOL

Each child gets blank piece of white paper and a pencil.

Say: “Draw a person in STEM”

If the child does not know what to do or delays for more than a minute, say: “What do you think someone in STEM looks like? Can you draw that?”
APPENDIX H. DRAW-A-STEM-PERSON FOLLOW-UP QUESTIONS

- Tell me about who you drew.
- Does this person have a name?
- Tell me about what they are wearing.
- What does this person’s work/life look like?
- What kinds of things do they do?
- Why do you think they are a person in STEM?
APPENDIX I. DRAW-A-BOY/GIRL PROTOCOL

Each child gets blank piece of white paper and a pencil.

Say: “Draw a boy/girl”

If the child does not know what to do or delays for more than a minute, say: “What do you think a boy/girl looks like? Can you draw that?”
APPENDIX J. DRAW-A-BOY/GIRL FOLLOW-UP QUESTIONS

- Tell me about who you drew.
- Does this person have a name?
- Tell me about what they are wearing.
- How do you know they are a boy/girl?
- What kinds of things do they do?
APPENDIX K: PHOTO SORT OF OBJECTS AND PLACES
APPENDIX L: PHOTOS OF PEOPLE IN STEM FROM PASPT

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<td><strong>STEM Context</strong></td>
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APPENDIX M. PHOTO ELICITED INTERVIEW QUESTIONS FOR STEM OBJECTS AND LOCATIONS

- Tell me why you think picture X is for boys/girls.
- Which of these do you like? Why?
- Are you familiar with any of the objects or places in these photos? How?
- Tell me why you think picture X is related to STEM or not.
APPENDIX N. PHOTO ELICITED INTERVIEW QUESTIONS FOR PASPT

- Tell me why you think is a person in STEM.
- How did you decide that person is or is not someone in STEM?
- What were your clues?
APPENDIX O. SCRIPTED PROMPT OF STEM DEFINITION

STEM stands for science, technology, engineering, and mathematics. S for science. T for technology. E for engineering. And M for Mathematics. STEM includes things like using knowledge and many skills to think about and solve problems as well as build and create new things.