ABSTRACT

ENNES, MEGAN ELIZABETH. Building Science Capital and Family Habitus Using a Systems Approach. (Under the direction of Dr. M. Gail Jones).

In this era of science and technology, it is important to foster life-long science, technology, engineering and mathematics (STEM) learning and interests. Science interests and career aspirations are influenced by a variety of factors including science capital and family science habitus. To examine the influence of families on the science interests and career aspirations of youth, a ten month, family intervention took place. The intervention took the form of a museum-based family STEM program aimed at increasing the science capital and family science habitus of families from nondominant groups and low wealth communities. The first study examined the effect of the program on the science expectancy value, science experiences, future science task value, and family science achievement values of the elementary youth (N = 45). Findings indicated that the program significantly increased the science expectancy value and science experiences of the youth participants. The second study used a mixed methods approach to examine the effects of the program on the cultural capital (science, social, familial, aspirational, linguistic, and navigational) and family science habitus of the parent participants (N = 44). The results suggest the program positively impacted the cultural capital and family science habitus of the parent participants. The third study examined access to science tools in the home. The reported access of the youth participants was compared to that of their parents. There were differences in perceived access of the youth to fundamental science tools such as a ruler compared to their parent. This suggests youth have access to hidden capital that may influence their science learning in school. The results of the overall study suggest that sustained family STEM programming is a useful tool for increasing the science interests and career aspirations of youth.

Building Science Capital and Family Habitus Using a Systems Approach

by
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DEDICATION

To all the kids, young and old, who love science but just don’t know it yet.

BIOGRAPHY

Megan grew up in the Midwest playing in the fields and streams. This led to an interest in marine biology and a move to the coast for college. Megan earned a degree in marine biology and science education from the University of North Carolina Wilmington (UNCW) in 2006. She then spent the next several years teaching in the Florida Keys and at an aquarium in the Smoky Mountains. Megan eventually returned to UNCW to earn a Master's in environmental studies with a focus in environmental education. During her time back at UNCW, she was hired as a full time educator at the North Carolina Aquarium at Fort Fisher. While working at the aquarium, Megan also taught environmental studies at UNCW. Her greatest accomplishments at the aquarium included a sea turtle STEM curriculum and teacher professional development as well as a film and curriculum on climate change that she developed with local high school students and presented in front of Congress and other governmental and nongovernmental agencies. Eventually, Megan decided she wanted to help other museum educators have more professional pathways to entering the field, so, she decided to attend North Carolina State University for a Ph.D. in science education focusing on informal science education. While at NC State, she was the first person in her department awarded a National Science Foundation Graduate Research Fellowship which allowed her to delve deep into research. Megan was fortunate to have a supportive cohort and extraordinary mentors during her program. She is looking forward to taking the knowledge she gained during her program and applying it to her next adventure.

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Next I must thank the army of volunteers who came out to help give surveys, interview parents and children, or even just help us support the museums in their programs. I want to especially thank Emily, Katherine, Pam, Rebecca, Mwenda, Katie, Katie, Dorothy, Lanette, Gina, Lyniesha, and Kathryn. We were also very fortunate to have some awesome undergrads including Sabrina and Christian.

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Finally, I'd like to thank my friends and family who helped support me on this journey. Thank you to mom and dad for knowing I was going to eventually get a Ph.D. even though I swore I never would. Their support during this process has been awesome. To Emily for traveling the world and back with me. To Katie, my first office mate and final accountability partner. To Rachel and Minnie for helping me have a place to live on a graduate student salary. To Kat who helped keep me sane and is always one of my biggest cheerleaders. To Trudy for being both a lap warmer and often a cognitive break whether I needed it or not. And certainly not last, a huge heartfelt thanks to my husband, Ryan, for making this process as smooth and painless as possible and for being open to whatever adventure the world brings us next!

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1: Introduction

The structure of this dissertation includes three stand-alone articles. The amount and types of data collected during this study led to the decision to write three separate papers better focus on specific facets of the program. This introductory chapter outlines the study as a whole, identifies some of the theoretical frameworks used, and introduces the three papers.

Science, technology, engineering and mathematics (STEM) learning and interests are becoming ever more important as society becomes more technical. This is central not just to increase the number of people, women and underrepresented groups, choosing to pursue STEM careers but also to develop a more scientifically literate citizenry. Being scientifically literate is vital when individuals need to make judgements about the reliability of scientific information as it relates to their decision making as citizens and supporters of the economy (Allchin, 2014).

STEM career aspirations are influenced by a wide range of factors including science self-concept (Shavelson, Huber, & Stanton, 1976), self-efficacy (Bandura, 1982), science capital, and family science habitus (Archer et al., 2012). While each of these are discussed in later chapters, of particular importance in this study were the concepts of science capital and family science habitus.

Science Capital

Science capital stems from Bourdieu's theory of social reproduction (Archer, Dawson, DeWitt, Seakins, & Wong, 2015). It refers to economic, cultural, and social resources related to the field of science (Archer, Dawson, DeWitt, Seakins, & Wong, 2015). This includes not only physical resources but also intangible resources such as relationships with people in the field of science.

Bourdieu (1986) described capital as representing the structure and function of the social world. He believed access to capital determines one's chance at being successful in one's endeavors. Capital has three basic states: economic, social, and cultural (Bourdieu, 1986). Economic capital can be turned directly into money and may also be seen as rights to property. Social capital is built of the social connections one has and is able to leverage. The cultural capital of an individual includes the knowledge, abilities, and cultural artifacts (such as books and art) an individual gains as part of his or her upbringing and education (Bourdieu, 1986). Science capital is a type of cultural capital.

Cultural wealth theory (Yosso, 2005) examines the forms of cultural wealth groups have available to them. In addition to science capital, paper two examines the other types of cultural capital parents have to support the science interests and career aspirations of their children. This includes social, familial, navigational, aspirational, and linguistic. Figure 1 summarizes the types of capital examined in this study. They are further described in Chapter 2.

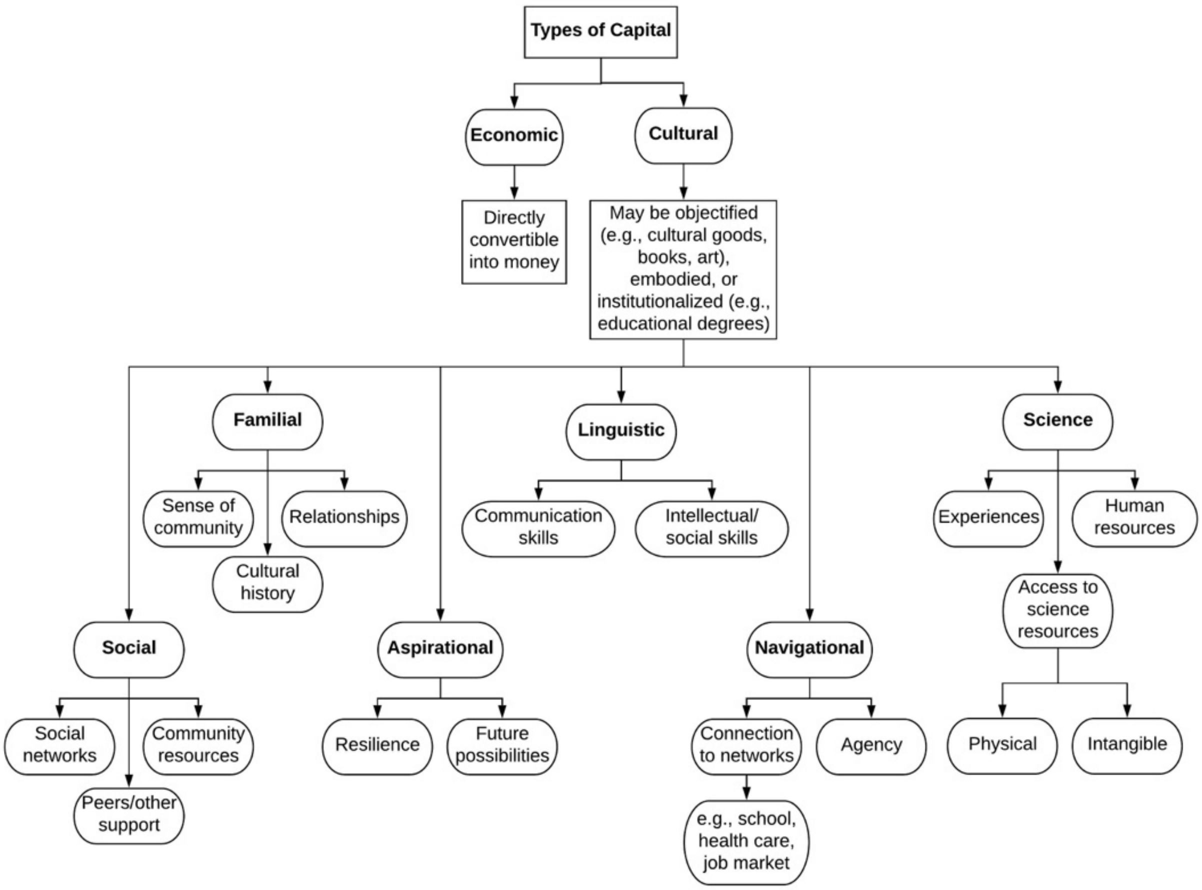

Figure 1: Forms of capital examined in this study. Adapted from Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education*, 8(1), 69-91.

Habitus

Cultural capital is foundational for the development of habitus (Bourdieu, 1973; Chandler, 2013). Habitus is a:

> System of lasting, transposable dispositions which, integrating past experiences, functions at every moment as a matrix of perceptions, appreciations, and actions and makes possible the achievement of infinitely diversified tasks, thanks to analogical transfers of schemes permitting the solution of similarly shaped problems (Bourdieu 1977, p. 95).

From a social-psychology perspective, individuals have of a series of internalized, cultural, interests that are constantly competing with one another (Chandler, 2013). Cultural capital influences these field specific interests (Chandler, 2013). A field is a socially structured environment that has its own set of rules and practices (Chandler, 2013). Science is one example of a field. The socialization of an individual into a particular field, such as science, at different points of their life will affect their habitus (Lizardo, 2004). Figure 2 summarizes the interaction of field, interests, habitus.

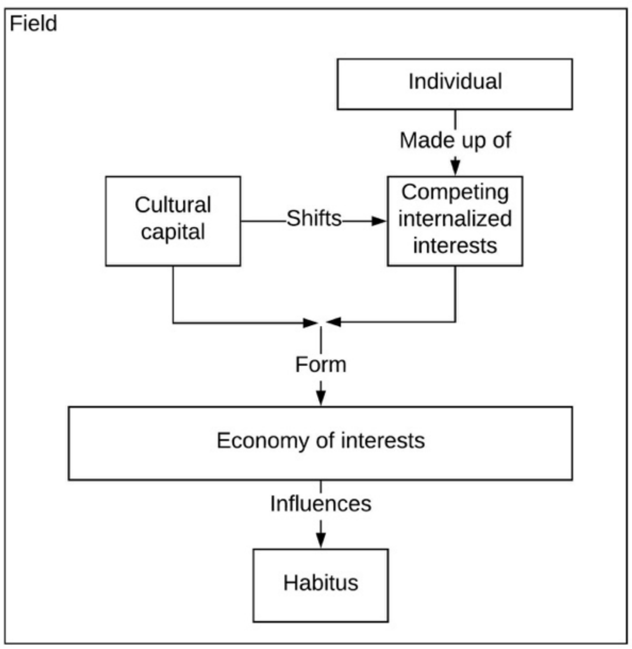

Figure 2: The interaction of field, agent, capital, and habitus. Adapted from Chandler, B. (2013). The subjectivity of habitus. *Journal for the Theory of Social Behaviour*, 43(4), 469-491.

One example of how habitus looks can be illustrated by a family that grows its own food and prioritizes healthy living. A child who grows up under this condition develops values, beliefs, and behaviors related to food choices. These values, beliefs, and behaviors will then influence their dispositions and future food choices.

Habitus is influenced by experiences (Chandler, 2013; Dumais, 2002; McClellend, 1990), observations of others (McClelland, 1990), an individual's place within society and how it is internalized by the individual (Dumais, 2002; McClellend, 1990), race/ethnicity, gender, socioeconomic status (Archer et al., 2012), and capital (Reay, 1995). Habitus directs the behaviors (Bourdieu, 1973), ways of speaking (Chandler, 2013; Silva, 2016), and belief systems (Archer & DeWitt, 2016; Silva, 2016) of an individual. Additionally, habitus shapes what an individual believes is typical of who they are (Archer and DeWitt, 2016), as well as what is possible or acceptable for them to achieve in the future (Archer et al., 2012). Figure 3 outlines habitus.

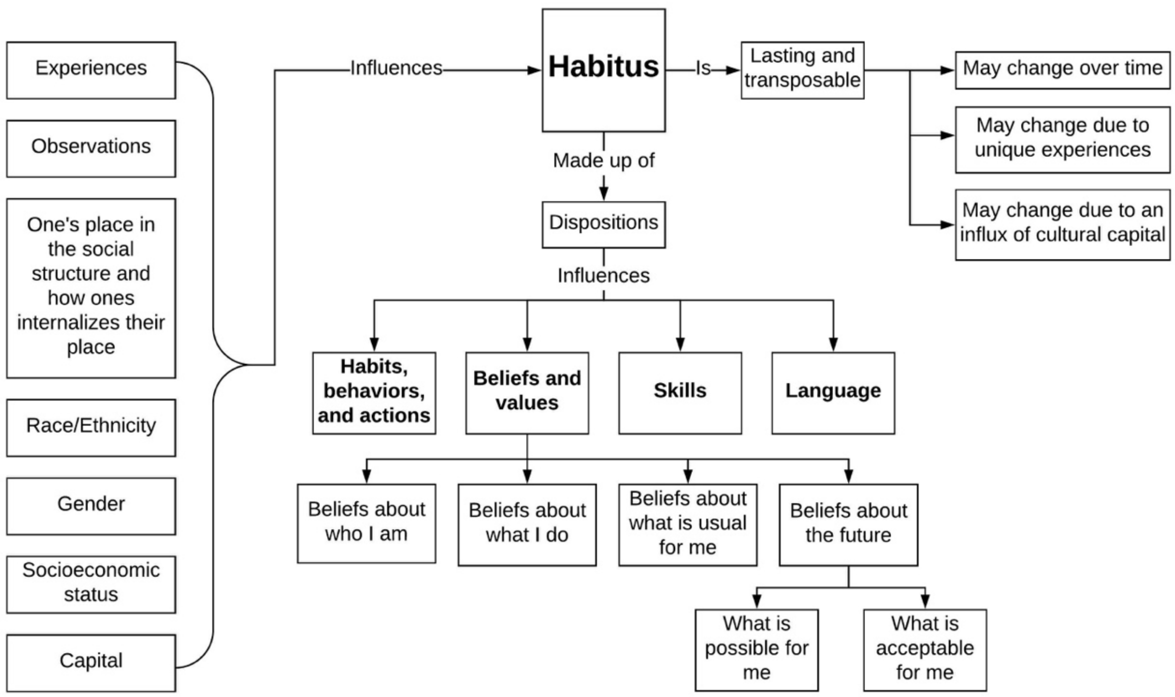

Figure 3: Factors influencing and influenced by habitus.

Archer and her colleagues (2012) describe family science habitus as the way a family's capital (economic, social, and cultural) may influence the way the family thinks, identifies, values, talks about, and engages in science. These beliefs, values, and capital a family holds may influence the worldview that a child may hold about science (Archer et al., 2012). A family's habitus is necessary to help youth be prepared to engage with the cultural capital of schools (Claussen & Osborne, 2013) as well as to engage in lifelong science habits and behaviors (Jones, Corin, Andre, Childers, & Stevens, 2016). As part of family science habitus, the types of experiences a family does or does not engage in, influences the science interests and career aspirations of the children. Several theories can be used to examine science interests and career aspirations including expectancy value theory (Wigfield & Eccles, 2000).

Expectancy Value Theory

Expectancy value theory (EVT) examines how an individual's values and expectations of success in a task influence the choices they make and their persistence and performance (Eccles & Wigfield, 2002). Many of the factors found in EVT align with the factors examined in this study. This study examined several factors that influence science capital, family science habitus: science expectancy value, science experiences, future science task value, and family science achievement values. These four factors were found to be psychometrically sound in the youth survey used in this study and will be described in more detail below (Jones, Ennes, Weedfall, Chesnutt, & Cayton, 2018 under review). The four factors were named based on constructs found in the EVT model. Figure 4 shows the factors examined in this study as they align with the EVT model.

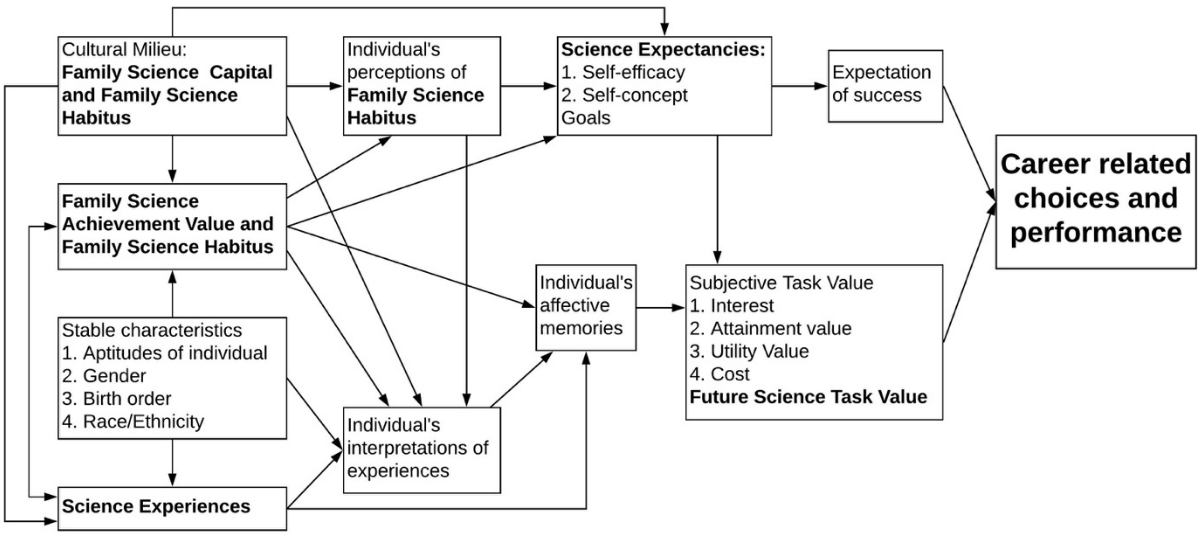

Figure 4: The model for expectancy value theory adapted to include factors related to science capital and family science habitus. Adapted from Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology*, 25(1), 68-81.

The Study

While science capital has been studied in the past (e.g., Archer & DeWitt, 2016), few, if any, studies have attempted interventions explicitly to increase the science capital and family science habitus of youth. This study arose from the hypothesis that increasing a family's science capital and family science habitus would lead to greater science interests and career aspirations of youth. To examine this hypothesis, a three year study was developed. Year one involved a nationwide survey of youth interest and access to STEM. Year two involved a ten month, museum-based, family STEM program aimed at increasing the science capital and family science capital of families from underrepresented groups and low wealth communities. Year three is currently ongoing and focused on assessing the impacts of the program in year two. This dissertation focuses on year two.

Study Context

The second year of this study involved the development and implementation of a ten-month, museum based, family STEM program. The goal of the program was to support and enhance the science capital and family science capital of families from underrepresented groups and low wealth communities. The program took place at three museums in a southeastern state of the United States. The museums included a natural sciences museum, a children's museum, and a planetarium and science center. The science museum was located in the center of an urban area. It was a state-run natural sciences museum and free to the public. The children's museum was also located in the center of an urban area. It was a play museum that focuses on early childhood. The third museum was a planetarium and science center run by a university and located on the campus.

Each museum recruited 20 families from underrepresented groups in low wealth communities through their connections with community organizations that were Title 1 schools or had after school programs. The museums were tasked with selecting elementary aged youth who had a STEM interest but limited access to science capital. Ten events were held at each museum including one joint event at each of the three sites. The events began with a communal meal to build community. This was followed by engaging STEM activities, STEM career information, interactions with STEM professionals, hands on technology activities, and items for each family to take home. These activities are described in more detail below.

To address any food security issues, to build community, and to foster family participation, each event began with a communal meal. Following the meal, the day's topic was introduced. This included themes such as astronomy, mammals, and engineering. Each event included engaging, hands-on STEM activities that were suited to the theme. It was expected that family members engage in these activities together so family cooperation was strongly encouraged. For example, during the gadgets and gizmos day, families worked together to build a parachute that was dropped from the second floor to see whose would fall the slowest. The families were also introduced to STEM professionals from the local community. During this time, the families were introduced to a variety of careers related to the day's topic and the guest speaker. A fundamental part of the program was technology that was embedded in several ways. This included a day on coding and the use of iPads that came pre-loaded with apps related to the day's theme. Before the families left at the end of the day, they received materials to continue the learning at home. To encourage attendance, families who attended at least six of the events were allowed to keep their iPad at the end of the year. These families also received a free week of summer cap for the targeted child at their home museum.

Data Collection

Survey instrument. In order to assess the influence of the program on the family participants, quantitative and qualitative data were collected. Each participant in the program was asked to complete the *NextGen Scientist Survey*. This survey was developed for a previous study and validated using the national data from year one in this study. For more information about validation of the survey, see Jones, Ennes, Weedfall, Chesnutt, and Cayton (2018, under review).

The elementary youth in this study (N= 45) took the youth version of the *NextGen Scientist Survey* (Appendix A). The *NextGen Scientist Survey* examines the science interests, capital, habitus, and career aspirations of youth. In a previous study, the survey was found to be psychometrically sound for four factors: science expectancy value, science experiences, future science task value, and family science achievement values (Jones et al., 2018 under review). Science expectancy values consists of nine questions related to science self-efficacy and science self-concept. This included questions such as "I know I can do well in science" and "My teacher see me as someone who likes science." Science experiences included 14 questions about out-of-school science experiences such as watching science related television or using a ruler. Future science task value was made up of three questions examining the career aspirations and their science task value. Examples include "I will need science for my job" and "After high school, I will use science often." Finally, family science achievement values, had four questions examining the youth's beliefs about their family's values related to science. Questions included "My family thinks it is important for me to learn about science" and "My parents have explained to me that science is useful for my future." Family science habitus and science capital have been shown to be influenced by these four factors (Jones, Ennes, Weedfall, Chesnutt, & Cayton, 2018 under review).

The parent version of the *NextGen Scientist Survey* (Appendix B) included questions about science interests (n=8), self-concept (n= 3), self-efficacy (n=4), career aspirations (n=1), science capital (n=6), family habitus (n=13), access to science tools (n=21), and science stereotypes (n=9). In addition to the questions from the pre survey, the post survey included three open-ended questions to find out more about the effects of the program on the families.

Case studies. In addition to the surveys, 12 families were selected to participate in case studies to gain better understanding of the influence of the program. Four families from each museum were selected to participate as case studies for a total of 12 families. Families were invited to participate in the case study after the youth participants' score on the pre survey was calculated. To determine this score, the mean score for each of five subconstructs were calculated. These subconstructs included science habitus (n=5), self-efficacy (n=6), science self-concept (n=5), informal science experiences (n=17), and science career aspirations (n=6). To determine their score, a final mean was found for each of the subconstruct mean scores. Youth were identified who had the lowest scores for each museum and they were offered an opportunity to participate in the case study. The case studies included three youth interviews, three adult interviews, and a mid-program survey. Additionally, the families were observed interacting with one another at least three times over the course of the year. Of the 12 families, 11 completed all of the data collection.

The parent interviews included questions about their demographics, science self-efficacy, science self-concept, their career and education, their future goals for their child, science experiences as a youth and an adult, their beliefs about science stereotypes, science capital, science interest, family habitus, their beliefs about their child, and their beliefs about museums and the program (Appendix C). The three youth interviews were made up of questions related to interest, science self-concept, access to STEM activities, family habitus, science knowledge, science self-efficacy, capital, parent education and career information, future science career aspirations, out-of-school science experiences, their beliefs about stereotypes in science, and their perception of the program. They were not examined for this dissertation.

The information from the qualitative and quantitative data was used to write three papers examining different effects of the program. A three paper format was chosen to give a broad understanding of the influence the program had on the various participants. The papers are described below.

Overview of Papers

Paper one. Paper one examines the effects of the program on the youth participants. The article reviews the literature related to family influence on the science career aspirations of youth. It draws from the theoretical frameworks of science capital (Archer et al., 2015), family science habitus (Archer et al., 2012), self-concept (Shavelson, Huber, & Stanton, 1976), self-efficacy (Bandura, 1978), and expectancy-value theory (Wigfield & Eccles, 2000). This quantitative paper uses the results from the *NextGen Scientist Survey* to investigate any differences in the four factors described above: science expectancy value, science experiences, future science task value, and family science achievement values.

Paper two. Paper two examines the influence of the program on the parent/guardian participants. The article describes the framework of community cultural wealth theory and science habitus. The literature review examines the influence of parents on the science interests and career aspirations of youth. This mixed methods study draws from the adult responses on the *NextGen Scientist Survey* as well as interviews with the case study parents to understand how the program influenced their different forms of cultural capital (science, social, familial, aspirational, linguistic, and navigational) and family science habitus.

Paper three. The third article examines the concept of hidden capital. In this study, hidden capital are resources to which an individual has access of which they may not be aware. As described in paper three, tools, both symbolic and physical, have emerged as foundational for learning (Vygotsky, 2001) and are an integral part of the discipline of science (Jones et al., 2000; Kirch, 2010). Tools play a fundamental role in making observations, analyzing data, and sharing results. They are also a form of science capital or resources associated with doing and learning science (Archer, Dawson, DeWitt, Seakins, & Wong, 2015). The *NextGen Scientist Survey* asks the participants about their access to tools and science related activities. The reported access of the youth was compared to that of the parents to identify areas of discrepancy. In the following chapters, each stand-alone paper is identified by their title and a brief abstract.

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Chapter 2: Building Science Capital and Habitus in Youth Though a Family STEM Program

Abstract

There has been a call to increase the number of women and individuals from nondominant groups in many fields of science, technology, engineering, and mathematics (STEM). Although there are many factors that influence the science interests and career aspirations of youth, an emerging area of research is that of science capital and family science habitus. This study examines the effects of a ten-month, museum-based, family STEM program on the youth participants. The youth participants (N = 45) completed the *NextGen Scientist Survey* pre and post program. The survey examines changes in the science expectancy value (related to self-efficacy and recognition), science experiences, future science task value (related to potential use of science in the future), and family science achievement values (related to parents' beliefs about science). The results showed that the program significantly increased the science expectancy value and science experiences of the youth participants. This suggests sustained museum-based, family STEM programs may help support science interests and career aspirations of youth.

Educators and policy makers have spent the last several decades targeting youth in hopes of increasing interest and career aspirations in the fields of science, technology, engineering, and mathematics (STEM). In 2016, the federal government spent over $2.9 billion on 163 STEM programs (Government Accountability Office, 2018). Despite these efforts to build students' career aspirations, many fields within STEM are still lacking equitable representation of women and minorities (Chen, 2013; Musu-Gillette, De Brey, McFarland, Hussar, Sonnenberg, & Wilkinson-Flicker, 2017; Snyder & Dillow, 2012). Emerging research has demonstrated the importance of family in building and supporting STEM interest and career aspirations (i.e., Archer & DeWitt, 2016; Crowley et al., 2001; Dabney, Chakraverty, & Tai, 2013; Jones, Taylor, & Forrester, 2011; Lee & Luykx, 2006; Maltese & Tai, 2010; Nugent, Barker, Welch, Grandgenett, Wu, & Nelson, 2015; Perera, 2014) however, few studies have examined how family programs may influence the development of STEM interests and career aspirations of youth.

Families and STEM

Families play a critical role in exposing their children to science through out-of-school experiences. Parents have the ability to encourage or discourage youth interest and participation in out-of-school STEM activities (Nugent et al., 2015). On average, Americans spend less than 5% of their time in school (Falk & Dierking, 2010), making out-of-school science experiences important for developing lifelong STEM interests and career aspirations. Research shows students are more likely to choose STEM careers in colleges after participating in out-of-school science activities (Dabney et al., 2012).

The goals of out-of-school science activities are often to increase science interest, science achievement, or both (Young, Ortiz, & Young, 2017). Children whose parents engage them in informal science experiences have been shown to have increased science literacy, a greater desire to keep learning about science topics, and an understanding that science is important to them as a family (Crowley et al., 2001). As youth spend the majority of their time with their families, it is important to support informal science experiences for families as a whole (Dabney, Tai, & Scott, 2016).

The choices and actions youth make are affected by their worldview, skills and past achievements, family demands, financial limitations, their environment, and other contextual factors (Andre, Whigham, Hendrickson, & Chambers, 1999). Youth build their science perspectives as part of their family unit, and families have a complex and vital role in developing youths' ideas of what is possible, probable, and desirable for them in terms of science and science careers (Archer, DeWitt, Osborne, Dillon, Willis, & Wong, 2012). Developing programs to support youth within their family and community structure can have long lasting, positive impacts (Dabney, Tai, & Scott, 2015).

Theoretical Frameworks

This study was informed by a number of salient theories: science capital (Archer et al., 2015), family science habitus (Archer et al., 2012), expectancy-value theory (Wigfield & Eccles, 2000), self-concept (Shavelson, Huber, & Stanton, 1976), and self-efficacy (Bandura, 1978).

Science capital and habitus. Family based programs may influence the science capital and science habitus of families. Family science habitus is the way a family engages in science as a result of their resources, behaviors, beliefs, and culture (Archer et al., 2012). Science capital is made up of the resources one has related to science including economic, cultural, and social resources (Archer, Dawson, DeWitt, Seakins, & Wong, 2015). Science capital is a form of cultural capital and exists in three states: the embodied state (i.e., the knowledge one has and the behaviors that are typical of the individual), the objectified state (i.e., cultural goods such as books, art, and other resources), and the institutionalized state (i.e., resources such as college degrees) (Bourdieu, 1986). Whether an individual has access to cultural capital is often used to explain why children from varying socioeconomic backgrounds have disparate levels of school achievement (Bourdieu, 1986).

An individual's science capital and family habitus can influence youth STEM career aspirations (Archer et al., 2012). Differences in family wealth may influence the science capital of youth as financial resources may limit the levels of parent engagement in science practices with their children or their knowledge about the pathways to pursuing STEM careers (Claussen & Osborne, 2013). Understanding the interactions of science capital, family resources, and family habitus can influence the design of educational interventions intended to promote STEM career awareness. As such, it is essential to examine the effects of STEM programs on the science capital and family habitus of youth.

Expectancy-value theory. Expectancy-value theory examines how an individual's choices, persistence, and performance in a task are influenced by their values and expectancies of future outcomes (Eccles & Wigfield, 2002). A task's subjective value is comprised of four components: attainment value, intrinsic value, utility value, and cost (Wigfield, Rosenzweig, & Eccles, 2017). Students who seeks to score well in a science fair because they have a high science self-concept exhibit attainment value whereas students who seek to score well in a science fair because they gain satisfaction from doing well do so due to their intrinsic value. When deciding to participate in a task, youth compare their future goals to the usefulness of completing the task, or its utility value. Additionally, students assess the amount of effort, emotional engagement, and the limits imposed by a task to determine the cost of participating in a task (Wigfield & Eccles, 2000). Finally, youth develop expectancies based on how well they believe they will perform on a task either at the present time or in the future (Wigfield & Eccles, 2000). A student who continually does well in his or her science courses in middle school, may develop expectancies that he or she will do well in high school.

The values and expectancies youth hold are developed within their family context and is influenced heavily by their parents (Jacobs & Eccles, 2000). A family's science capital and habitus may influence a child's career aspirations by offering past experiences to draw from as well as through the behaviors and beliefs of their parents. A child's interpretation of their parents' values and dispositions regarding science as well as their past experiences with science can influence their science self-concept and science self-efficacy which in turn influences their expectancies (Jacobs & Eccles, 2000).

Science self-concept and self-efficacy. Self-concept is an individual's perception of self based on experiences within social and physical environments, reinforcement from external factors, and significant people in his or her life (Shavelson, Huber, & Stanton, 1976). Self-concept may affect an individual's behavior which in turn influences his or her perception of self. Science self-concept is often compared to science self-efficacy. While academic self-concept is considered to be an individual's perception of him or herself and his or her present academic abilities, self-efficacy is an individual's beliefs regarding their ability to complete specific academic tasks in the future (Bong & Clark, 1999). Self-concept, as summarized by Bong and Clark (1999) is built upon a self description of one's ability to do a task and how well they can complete a task, as well as their affective feelings, or self-worth associated with a task. Comparably, self-efficacy primarily focuses on the self-assessment of one's future ability in a specific domain (Bong & Clark, 1999). Self-efficacy is foremost a cognitive judgement of one's abilities whereas self-concept is a cognitive judgement as well as evaluative and affective (Bong & Clark, 1999). Both self-concept and self-efficacy are essential factors to consider when examining the career aspirations of youth as they determine whether an individual feels capable of being successful in STEM fields. Building and sustaining the science self-efficacy of youth may encourage more youth to major in science or pursue science careers (Potvin & Hasni, 2014).

In addition to personal experiences of youth, their parents' values also play an important role in shaping their self-perceptions and values in specific domains such as science (Jacobs & Bleeker, 2004). Eccles and her colleagues (1983) developed a model examining several pathways in which parents influence their children's decisions. The factors of particular interest in this study included parent provided experiences, parents' role modeling, and parental communication about their expectations and perceptions of their child's abilities and performances. The message, environment, and modeling parents exhibit for their children about the value they place on a particular activity have been shown to influence a child's motivation to pursue a task (Jacobs & Eccles, 2000). The need for parents to give youth a context in which to learn to value an activity by building interest and engagement has also been tied to task value.

Using expectancy value theory, this study examined four factors that influence science capital and family science habitus: science expectancy value, science experiences, future science task value, and family science achievement values. These factors have been psychometrically validated for the survey used in this study (Jones, Ennes, Weedfall, Chesnutt, & Cayton, 2018 under review). Three of the four factors were named based on constructs found in the EVT model. Science expectancy includes questions related to science self-efficacy and self-concept. Future science task value examines the utility of science in their future. Family science achievement value evaluates the beliefs youth hold about their family's interest and expectations about science. Figure 1 shows these factors as they align with the EVT model.

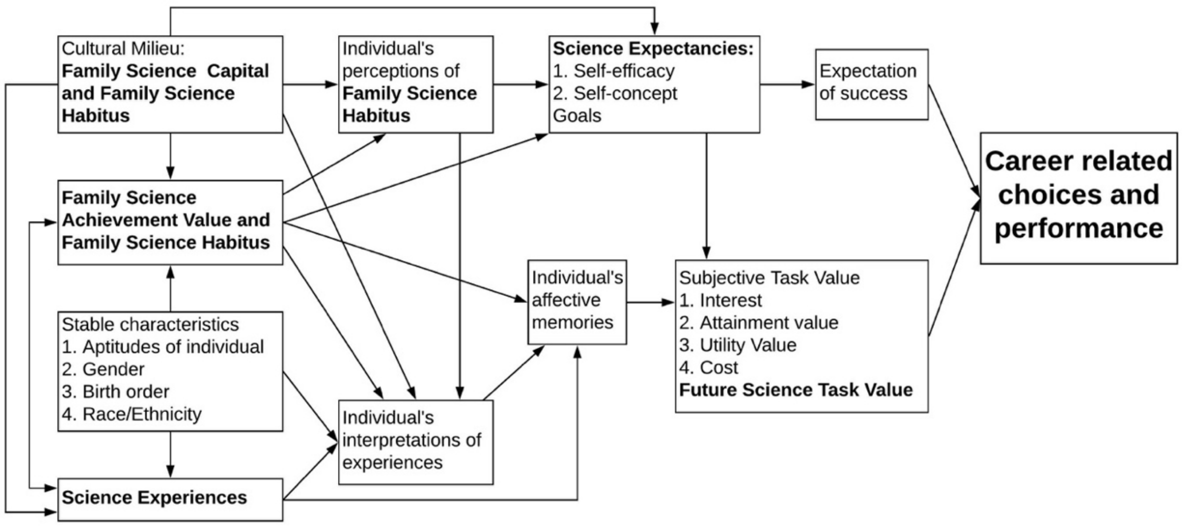

Figure 1: The model for expectancy value theory adapted to include factors related to science capital and family science habitus. Adapted from Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology*, 25(1), 68-81.

Study Context

Guided by the framework of expectancy value theory, researchers developed a museum-based family STEM program at three museums in a southeastern state of the United States: a children's museum, a science museum, and a planetarium. The children's museum is located in the center of an urban area. It is a play museum that focuses on early childhood. The science museum is also located in the center of an urban area. It is a state-run natural sciences museum and is free to the public. The third museum is a university-run planetarium and science center located on a large university campus.

The program, called FAME: Families and Museums Exploring, was built on the theory of action that if we enhanced the science capital and family habitus of elementary youth and their families, we would be able to increase the science interest, self-efficacy, and out-of-school

STEM experiences of youth, which would ultimately lead to an increase in their STEM career aspirations. This study examined the youth participants in the program.

Research Question

The study presented here fills gaps in the literature by examining whether family-based programs may influence the science capital and family science habitus of youth. The overall goal was to build family science capital and ultimately influence students' STEM career goals. The following research question guided the data collection and analyses: How does participation in a year long, museum-based, family STEM program influence the science expectancy value, science experiences, future science task value, and family science achievement values of youth?

Methods

The study took place over the course of one school year in collaboration with three museums in the southeastern United States: a children's museum, a science museum, and a planetarium. The program approached STEM learning from a systems perspective and engaged the child and his or her family (broadly defined by the families themselves) in exploring STEM together. In addition to family, the model, outlined in Figure 2, included friends, a community of other families, STEM resources, engaging STEM activities, museum educators, and mentors.

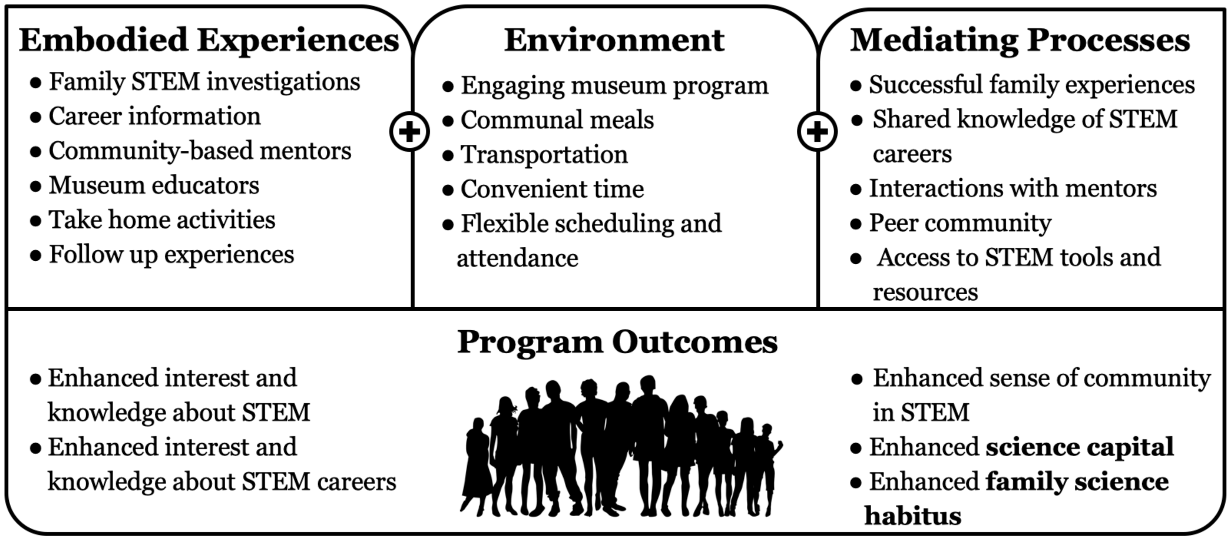

Figure 2: Museum-based, family STEM program model. This figure illustrates the components and outcomes of the program.

As part of the study, each museum recruited 20 families from low wealth, underrepresented groups using their connections with community organizations that had after school programs. Elementary aged youth were selected who had expressed an interest in STEM, but had limited access to science capital. Each museum held ten events over the course of the year including one that hosted the families from the other two museums. Each event included a communal meal followed by hands-on STEM activities, STEM career information, presentations by STEM professionals, technology-facilitated activities, and take-home activities for each family. These activities are described in more detail below.

The communal meal was intended to build community, facilitate family participation, and address any food security issues related to the program. The meal was followed by an introduction to the day's theme such as computer coding, bird banding, or geology. During the program, each museum provided hands-on STEM activities related to the day's theme. A unique aspect of this program was that family members were expected and encouraged to engage in science activities together. For example, during the coding day, families were introduced to computer coding by working together to build a Rube Goldberg machine. During each program, the families also met community STEM professionals related to the day's topic and learned more about related careers. The family programming also encouraged the use of technology to complement each day's theme. For example, families were provided iPads pre-loaded with apps which allowed them to explore topics such as leaf identification or constellations. At the end of each event, families were presented with activities and materials to continue exploring the day's topic at home.

Survey Instrument

In this quasi-experimental study (Gall, Gall, & Borg, 2003), each elementary aged youth participant (N = 45) took the *NextGen Scientist Survey* (described below) at the first and last events of the year, or at least eight months apart. The surveys were administered with paper and pencil and later digitally transcribed. The surveys were offered in both English and Spanish.

The *NextGen Scientist Survey* was developed for a previous study to examine science interest, capital, habitus, and career aspirations of youth (Appendix A). The final iteration of the instrument was analyzed with a confirmatory factor analysis (CFA). The instrument was shown to be psychometrically sound for middle grades students on four factors: Factor 1: science expectancy value, Factor 2: science experiences, Factor 3: future science task value, and Factor 4: family science achievement values (Jones et al., 2019 under review). The science expectancy value factor was made up of nine questions related to self-efficacy and science self-concept. This included questions such as "I know I can do well in science" and "My parents see me as someone who likes science". The science experiences factor included 14 questions asking how often an individual had participated in out-of-school science activities such as using a thermometer to measure temperature or going on a nature walk. Future science task value included three questions that examine the career aspirations of the youth and their perceived task value of science. Examples include "I will need science for my job" and "After high school, I will use science often." The last factor, family science achievement values, included four questions that examine the youth's perception of their family and parents' beliefs about the intrinsic value, utility value, and attainment value of science. Questions included "My family thinks it is important for me to learn about science" and "My parents have explained to me that science is useful for my future." These four factors have been shown to be related to the science capital and family habitus of youth (Jones et al., 2018 under review).

Participants

Forty-five youth and their families completed the nine-month program and took both the pre and post assessments. The youth were identified for participation by teachers or community after school programs who nominated students with an interest science or who were from underrepresented groups or low wealth families. Additional youth were identified by parents who applied to participate at the partner museums. The museums then selected youth who expressed an interest in science on their application, but appeared to lack access to science capital.

The targeted youth (N = 44) included those in third grade (40.9%), fourth grade (40.9%), and fifth grade (18.2%). Of the youth who reported their age (n = 40), 12.5% were 11 years old, 17.5% were 10 years old, 40% were 9 years old, and 30% were 8 years old. Of the youth participants who reported their gender (n = 44), 52.3% identified as female and 47.7% as male. The youth (n = 44) identified as 63.6% African American, 25.0% Latinx, 6.8% White; and 4.5% other. Of the youth, 11.4% indicated that they spoke Spanish and 9.1% spoke another language other than English at home.

Analysis

Survey participants were removed (n = 3) if they did not complete both the pre and post surveys, resulting in a pool of 45 youth. Wilcoxon Signed Rank tests were calculated to measure changes in individual participants from pre to post for the factors of science expectancy value, science experiences, future science task value, and family science achievement values. Individual items within each factor were examined using a paired t-test to look for significant changes from pre to post assessments for each participant. The questions for science expectancy value, future science task value, and family science achievement values were on a five-point Likert scale from strongly disagree (1) to strongly agree (5). Questions related to science experiences were on a four-point scale asking how often youth participated in different activities. The choices were "never" (0), "one time" (1), "two to four times" (2), or "five times or more" (3).

Results

This study examined how participation in a year long, museum-based, family STEM program influenced factors associated with science capital and career aspirations (science expectancy value, science experiences, future science task value, and family science achievement values of youth). The results related to these factors are described in the sections that follow.

Science Expectancy Value

For science expectancy value, the participants initially had a mean score of 3.65 (SD = 0.86) and post-survey mean score of 3.81 (SD = 0.91), which was a significant increase ($z(44) = -1.93$, $p = .05$). However, there were no significant changes from pre to post for any individual item that made up Factor 1. See Table 1 for comparison of the four factors for the youth.

Table 1: Comparison of pre- and post-scores for the four factors. This table examines the change in mean youth scores for each factor from pre to post (N = 45).

Factor	Pre-Score		Post-Score				
	M	SD	M	SD	*z*	*p*	Effect[a]
Science Expectancy Value[b]	3.65	0.86	3.81	0.91	-1.93	.05*	0.29
Science Experiences[c]	1.38	0.67	1.57	0.74	-2.22	.03*	0.33
Future Science Task Value[b]	3.57	0.98	3.48	1.00	-0.44	.66	0.07
Family Science Achievement Values[b]	3.59	0.94	3.56	0.94	-0.13	.90	0.04

Note: [a] The absolute value was calculated for effect size; [b] These items are on a 1-5 Likert scale; [c] This item is on a 0-3 Likert scale. *$p \leq .05$.

To see if there was a differential impact on students based on their self-efficacy for science, scores were examined by science expectancy value quartile scores. The top and bottom quartiles were compared. The youth in the bottom quartile for science expectancy value pre-scores had a statistically significant change from pre to post, z(10) = -2.76, p = .01. There were no significant changes for any other factor for this group of youth in the upper quartile. (Table 2)

Table 2: Comparison of factor pre and post-scores of the bottom quartile group (quartiles based on pre-score of factor 1, n = 11)

Factor	Pre- Score		Post-Score				
	M	SD	M	SD	*Z*	*p*	Effect[a]
Science Expectancy Value[b]	2.43	.57	3.27	.83	-2.76	.01*	0.83
Science Experiences[c]	1.30	.70	1.30	.53	-.09	.93	0.03
Future Science Task Value[b]	2.85	.95	3.33	1.26	-1.48	.14	0.45
Family Science Achievement Values[b]	2.95	.81	3.25	.99	-1.25	.21	0.38

Note: [a] The absolute value was calculated for effect size; [b] These items are on a 1-5 Likert scale; [c] This item is on a 0-3 Likert scale. *$p < .01$.

Science Experiences

For Factor 2, science experiences, the participants had an initial mean score of 1.38 (SD = 0.67) and a post mean score of 1.57 (SD = 0.74) which was a significant increase, z(44) = -2.22, $p = .03$ (Table 2). Of the individual questions that made up Factor 2, there were significant increases from pre to post for four items. Youth reported a significant increase in the number of times they had gone to a museum, zoo, aquarium or planetarium outside of school ($t(44) = 2.04$, $p = .05$). They also reported a significant increase in the number of times they had done experiments or used science kits outside of school ($t(44) = 2.05$, $p = .05$). Additionally, youth reported an increase in their experiences with tools and materials. There was a significant increase in the number of times participants reported using a ruler, measuring tape, or measuring stick outside of school ($t(42) = 2.02$, $p = .05$). Respondents also reported a significant increase in the number of times they had built or taken things apart like a radio, watch, or computer outside of school ($t(44) = 2.22$, $p = .03$). (Table 3)

Table 3: Changes in science experiences pre to post.

When not in school how many times have you:	Pre M	Post M	ΔM	SD	SE	t	df	*p*
Built or taken things apart like a radio, watch, or computer?	0.69	1.16	.47	1.41	.21	2.22	44	.03*
Gone to a museum, zoo, aquarium, or planetarium?	1.71	2.07	.36	1.17	.18	2.04	44	.05*
Done experiments or used science kits?	1.38	1.82	.44	1.46	.22	2.05	44	.05*
Used a ruler, measuring tape, or measuring stick?	1.72	2.00	.35	1.13	.17	2.02	42	.05*
Read a map to find your way?	0.82	1.18	.36	1.46	.22	1.63	44	.11
Collected shells or rocks?	1.93	2.18	.24	1.19	.18	1.38	44	.18
Used a thermometer to measure temperature?	1.02	1.29	.27	1.37	.20	1.30	44	.20
Used binoculars or a telescope?	1.31	1.51	.20	1.27	.19	1.06	44	.30
Planted seeds and watched them grow?	1.29	1.40	.11	1.19	.18	0.63	44	.54
Talked about science related topics with other people?	1.62	1.73	.11	1.34	.20	0.56	44	.58
Done science activities like scouts, 4-H or science camps	1.18	1.07	-.11	1.56	.24	-0.48	43	.63
Read a book or magazine about science?	1.39	1.29	-.07	1.50	.23	-0.30	43	.77
Watched science TV programs?	1.47	1.47	-.04	1.22	.18	-0.24	44	.81
Gone online to learn about science on science websites or videos?	1.40	1.36	-.04	1.26	.19	-0.24	44	.81
Gone on a nature walk?	1.62	1.60	-.02	1.31	.20	-0.11	44	.91

Note. $*p < .05$

Future Science Task Value and Family Science Achievement Values

Factor 3, Future Science Task Value, and Factor 4, Family Science Achievement Values, were examined for changes from the pre to post survey, and there were no significant differences for the factors or individual items that made up the factors. (Table 1) When examining the distribution for these two factors on the presurvey, the youth reported high initial levels for Factors 3 and 4. As noted above, there were no changes for youth in the upper or lower quartiles for these two factors.

Discussion

With the continual call for greater diversity of youth choosing to pursue STEM careers, it is important to approach the problem from many avenues. Developing programs to support youth and their families has emerged as an important line of research as family plays a foundational role in supporting the development of career aspirations of youth. This study found that participation in a year long, museum based, family STEM program increased two of the four factors associated with science capital and family habitus: science expectancy value and science experiences. These factors have been shown to play an important role in the development of science career aspirations of youth (Archer & DeWitt, 2016). Given the relatively short period of time that participants were in the program it would be interesting to follow-up in future years to see if career aspirations were influenced.

When examining the pre-scores for the four factors, science expectancy value, future science task value, and family science achievement values were already high. This made it difficult to raise the youth's perceptions of these factors. However, this study found that the family STEM program led to significant increases in science expectancy value and science experiences of the youth participants. The factor science expectancy value was made up of items related to science self-efficacy and self-concept. Both of these factors may contribute science career aspirations as high levels of self-efficacy and outcome expectancies have been shown to lead to the development of career aspirations (Carlone & Johnson, 2007; Ferry, Fouad, & Smith, 2000; Lent, Brown, & Hackett, 2006; Nugent et al., 2015).

The self-efficacy of the youth participants in this study may have been influenced by the family science programming in multiple ways. In this study, youth participants were required to bring at least one adult family member (defined broadly) to each event. Some participants brought a parent but others brought a grandparent, stepparent, or social worker. This ensured the youth had multiple, extended opportunities to engage in science with their family. This approach was supported by a study by Ferry, Fouad, and Smith (2000), who found that having multiple opportunities to engage in hands-on, out-of-school science with their parents led to an increase in the science self-efficacy of the participants. Social support that promotes positive self-efficacy towards science has been shown to be vital to support future science career aspirations (Rice, Barth, Guadagno, Smith, & McCallum, 2013). In a review of the literature surrounding interest, motivation, and attitudes regarding science and technology career aspirations, researchers found that the science self-efficacy of youth must be nurtured if the goal is to encourage them to pursue careers in these fields (Potvin & Hasni, 2014). They also found that positive experiences in informal science may prevent a decline in science and technology career aspirations by supporting the self-efficacy of youth and therefore their interest, motivation, and attitudes towards science (Potvin & Hasni, 2014). The results of this study showed an increase in science self-efficacy as part of the science expectancy value factor. If this program was able to raise the self-efficacy of the participants, it is possible it may lead to an increase or strengthening of their science career aspirations.

Recognition and social support are also important in developing interests in science and science experiences. In a study of science hobbyists, Jones and colleagues (2016) found that interactions with friends and family members were responsible for the development of childhood STEM interests. Additionally, they argue that if youth do not know anyone who engaged in STEM, either as a leisure activity or a career, they were unlikely to develop STEM career aspirations (Jones, Corin, Andre, Childers, & Stevens, 2016; Corin, Jones, Andre, & Childers, 2017). Therefore, engaging youth in science experiences with their family, as in this study, is vital to developing and supporting STEM career aspirations.

Out-of-school engagement with science, such as those activities that make up the science experiences factor, are an important part of science capital and habitus. Out-of-school science experiences may raise the interest and self-efficacy of youth related to science (National Governors Association, 2012). Parents play an important role in these types of experiences as they act as gatekeepers for out-of-school science activities (Nugent et al., 2015). Cost, location, and languages are just a few of the known barriers to Latino and African American participation in informal education (Bruyere, Billingsley, & O'day, 2009). This program may have increased the number of opportunities to participate in informal science experiences as the program offered free programming, museum memberships, and other science-based experiences. This study found that participants reported a significant increase in the number of science experiences they had outside of school this year.

For individual activities within the science experiences factor, the participants reported on the post-survey that they were spending more time doing science outside of school in activities such as using science kits, measuring items, and tinkering. Dabney and colleagues (2012) suggest that these types of experiences are particularly important for females and youth from low-wealth families because without exposure to these activities they may not develop an interest in science. These informal types of experiences are important in developing science interests, self-concept, and content area knowledge (Martin, 2014; National Research Council, 2009) which may then lead to greater STEM career aspirations (Archer & DeWitt, 2016). The program in this study sent each family home with a kit of materials following every event. This increased the number of opportunities youth had to engage with science materials and therefore potentially increasing their science capital.

The results for the future science task value factor and the family science achievement values factor did not change significantly. However, this was likely due to the ceiling effects on the pre-assessment for the future science task value factor and the family science achievement values factor. These survey items investigated whether participants felt they would use science in the future and whether they felt their family valued science. The youth may have seen science as valued by their family since their family chose to participate in the program. To test this program model further, future studies could examine youth who fit different science interest profiles (such as those with low expressed science interest) as they participate in the program model. The youth selected for this program were chosen based on an expressed interest in science, but limited access to science capital.

Limitations and Suggestions for Future Research

The participants in this study were volunteers who may have self-selected to participate due to a preexisting interest or prior experiences with STEM. The youth who participated in this study were selected based on an interest in science but limited access to science capital. However, the community where the program took place had many STEM resources and opportunities to experience STEM outside of the program. This may not be typical of youth more broadly and care must be taken when generalizing these results to other populations. Additionally, many of the youth who participated in the program were also enrolled in a local after school program which may have involved STEM activities as part of the curriculum. Future research is necessary to assess the application of this program in other settings (i.e., rural, suburban) to test the effectiveness and investigate the possibility of increasing the STEM career aspirations of youth in various settings.

Conclusions

In order to foster lifelong STEM learning and interests in this era of science and technology, it is important to support science interests from a young age. There are many factors that influence science interest and career aspirations of youth including family science capital and habitus, along with the development of science self-concept and self-efficacy (Archer & DeWitt, 2016). This study showed the value of family STEM programs in increasing the science capital and habitus of youth particularly for science expectancy value and science experiences.

While many STEM interest interventions for youth have focused on individuals, this study examined the effects of family engagement on the science capital and habitus of youth. The results of this study suggest that this emphasis on the family involvement is a critical element of programming designed to increase the science expectancy value and out-of-school experiences of youth, important facets of science capital and habitus. This research provides additional insight into potential avenues for developing lifelong science interests and career aspirations of youth. This is particularly important for youth from underrepresented or low socioeconomic groups. If schools or museums offer programs similar to this one, they may increase the science capital and family habitus of the youth they serve.

The model used in this program included communal meals, followed by hands-on STEM activities, STEM career information, presentations by STEM professionals, technology-enhanced activities, and take-home activities for each family. The program helped build the science capital of youth by increasing their resources through take home activities, adding to their network of STEM professionals, and increasing their knowledge about various STEM topics. It also helped build family science habitus by increasing the number of out-of-school science experiences the families participated in. Participating in family science events has been shown to increase parental interest in participating in future science events (Yanowitz & Hahs-Vaughn 2016) which may lead to an increase in family science habitus over an extended period of time.

Based on the results of this study, educational institutions such as schools and museums should develop science programming that engages the entire family. This is supported by previous research that has shown the importance of parental involvement on youth science interests and career aspirations (e.g., Bruyere, Billingsley, & O'Day, 2009; Dabney, Tai & Scott, 2015; Yanowitz & Hahs-Vaughn, 2016). Each youth participant was required to bring one adult family member with them to each program. This ensured that the youth had social support from someone in their family. Schools and museums should consider finding ways to allow parents to be more involved in their child's science experiences.

While previous research has sought to quantify the science capital and family science habitus of youth (e.g. Archer & DeWitt, 2016), few have sought to change them. The results in this study suggest that family STEM programs may be an effective avenue to build and support the STEM career aspirations of youth through an increase in science capital and family science habitus. STEM interventions should include youth and their communities in order to increase the number of women and unrepresented youth pursing STEM careers.

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Chapter 3: Building the Cultural Capital and Science Habitus of Parents in a Family STEM Program

Abstract

Emerging research suggests that families are a foundational piece in developing the science interests and career aspirations of youth. Many factors play a role in the influence parents have on their children's science interest including their science capital and family science habitus. This study uses community cultural wealth theory to examine the impacts of a sustained, museum-based family STEM program on the adult participants (N = 44). Parents of youth participants completed a survey and 11 of the parents participated in intense case studies. The results showed that the program increased parent access to cultural capital, including science, social, familial, navigational, aspirational, and linguistic capital, as well as their family science habitus. The results suggest this increase in science habitus may influence parental support for their children's career aspirations The results of this study suggest that a ten-month, museum-based family STEM program can be an effective strategy for building family science capital and habitus.

> *I think if I [had] had more access and more knowledge, more experience, more understanding of the different ways science is used and how fun it is [I might have considered a career in science]. I don't think I saw the joy in science. I just looked at vocabulary words and I thought you had to go to school for twenty years to do it. And I didn't understand the ins and outs and the different careers.* Ayanna (program parent, final interview)

Perhaps there is no greater influence on a child's life than that of a parent. Parents play an important role in educating youth (Wilson & Gross, 2018), influencing them through their family habitus and capital (Davis-Kean, 2005). Capital refers to tangible and intangible resources whereas habitus is made up of dispositions that influence behaviors and decision making (Bourdieu, 1986). Habitus influences the types of activities families engage in together and parents are typically responsible for the types of experiences to which a child is exposed. Early experiences in science play a fundamental role in the development of science career aspirations (Dabney, Chakraverty, & Tai, 2013). For example, professionals and hobbyists in science, technology, engineering, and mathematics (STEM) fields often credit their parents with being responsible for their early exposure to and interest in STEM (Dabney, Tai, & Scott, 2016; Jones, Taylor, & Forrester, 2011; Moore, 2006; Sonnert, 2009). Having parents who promote career awareness and encourage career exploration has emerged as an important type of capital that plays essential roles in career aspirations (e.g. Ceglie, & Settlage, 2016; Moore, 2005; Sonnert, 2009; Workman, 2015).

This study set out to identify whether it was possible to build upon the resources parents already have to help them better increase and support the science interests and careers aspirations of their children. This was done by leveraging the community cultural wealth the parents already had to increase the tools they had access to and by increasing their family science habitus. These two foundational concepts are described in depth below.

Community Cultural Wealth

The community cultural wealth framework describes the types of knowledge, connections, and capabilities a community possesses (Yosso, 2005). Community cultural wealth examines the assets communities possess which may be leveraged rather than approaching issues from a deficit perspective. Within this framework, cultural capital is made up of several interacting forms including, but not limited to, social, aspirational, familial, navigational, and linguistic capital (Yosso, 2005). These types of capital are dynamic, interact with one another, and play a role in building each other (Yosso, 2005).

The system of relationships and resources an individual develops through interactions with other people and communities builds social capital (Bourdieu, 1986; Yosso, 2005). This includes the networks of people an individual knows such as family, friends, teachers, and other community members. These resources and relationships are important for helping an individual comprehend and negotiate institutions such as school, the medical field, or even the field of science (Yosso, 2005).

Aspirational capital allows an individual to have goals and ambitions for the future despite any barriers they may perceive or experience (Yosso, 2005). This form of capital enables individuals to have goals for themselves, or others, that may appear to lay beyond their current situation and means. A study with African American males in engineering found that parents were an important source of aspirational capital that helped the participants pursue engineering degrees despite barriers (Moore, 2006). Additionally, a study examining Latinx parents' beliefs about STEM education found that many parents held high aspirations for their children's academic achievement regardless of the barriers they may face (Hernandez, Rana, Alemdar, Rao, & Usselman, 2016).

Familial capital is considered an expansion of social capital and is often described interchangeably with family capital or family social capital (Williams & Dawson, 2011). Familial capital includes the forms of cultural knowledge within a family such as a shared history or memories and includes a broad concept of family which includes extended family and non-relatives (Yosso, 2005). Familial culture varies among different ethnic, socioeconomic, and cultural groups (Kiyama, Harper, Ramos, Aguayo, Page, & Riester, 2015). For African American families, familial culture plays an important role due to the foundation of communities that traditionally focus on family, church, the neighborhood, often including extended family members- both real and unrelated individuals (Hunter, Chipenda-Dansokho, Tarver, Herring, & Fletcher, 2018). Familial culture is an important part of Latinx families as the family is often the main source of socialization for Latinx youth, teaching them how to behave in social settings (Duran & Pérez, 2017).

Navigational capital is what allows individuals to negotiate social institutions (Yosso, 2005). Often social networks developed through familial capital and/or social capital play a role in allowing individuals to navigate institutions such as school or applying for college and then jobs (Yosso, 2005). For example, part of an adolescent's navigational capital would include knowing about careers, how to find information on applying for college, and how to ask adults for letters of recommendation. When examining Latinx parents' beliefs about STEM education, researchers found that many Latinx parents felt they lacked knowledge about how to navigate the college application process, apply for scholarships, and other information about college preparation (Hernandez et al., 2016).

Linguistic capital is a result of learning to communicate in more than one language or style and is associated with a set of intellectual and social skills (Yosso, 2005). Language plays an important role in allowing individuals access to institutionalized capital in areas such as science (Claussen & Osborne, 2013). For example, Linguistic capital is representative of the languages and communication skills that youth from nondominant backgrounds often bring with them (Yosso, 2005). Many fields, such as science have their own language. How youth discuss and interact with science is developed over time through interactions with their parents and out-of-school science experiences such as science hobbies or visits to museums (Claussen & Osborne, 2013).

Another form of cultural capital is science capital. Science capital refers to the resources (economic, cultural and social) one has related to science (Archer, Dawson, DeWitt, Seakins, & Wong, 2015). Social capital also plays an important role in science capital. Each individual in one's social network also brings their own capital which, in turn, increases the capital of the individual. In terms of science capital, this network is important for introducing an individual to people who are scientists or have science hobbies, in order to expose the individual to these experiences. These forms of capital are summarized in Figure 1.

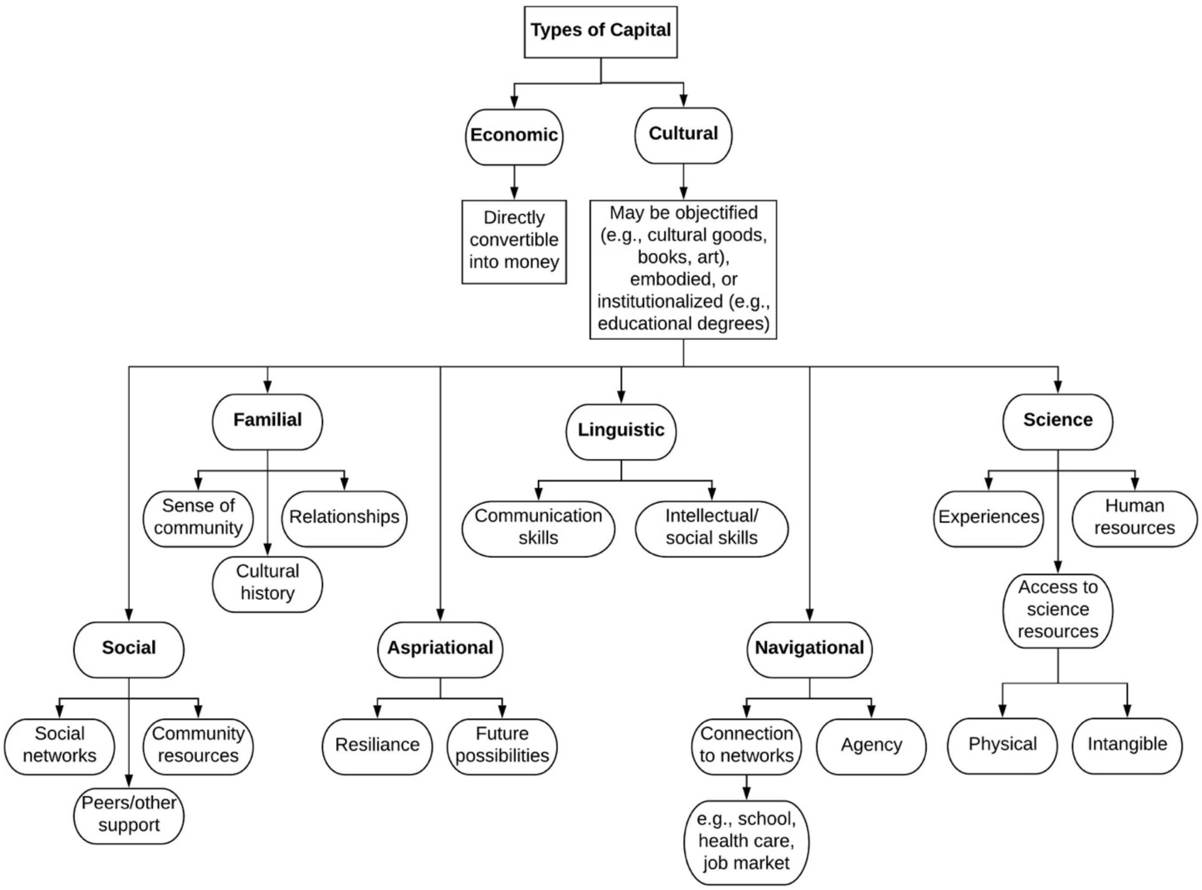

Figure 1: Forms of cultural capital. Adapted from Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race ethnicity and Education*, 8(1), 69-91.

When examining career aspirations, it is important to include these various types of capital as they are dynamic and influence one another (Yosso, 2005). For example, science career aspirations develop within the family and social arenas and are therefore influence by familial and social capital. Linguistic and navigational capital give an individual the tools needed to pursue a science career by allowing the individual to know what steps need to be taken as well as allowing the individual to speak the "language" of science necessary to be successful. Finally, science capital gives individuals the tools needed to see themselves as someone who is capable of pursing a science degree. Because of the interplay between these forms of cultural capital, it is important to examine them together rather than individually.

Habitus

Cultural capital, such as the forms within the community cultural wealth theory, plays an important role in shaping an individual's habitus (Bourdieu, 1973; Chandler, 2013). From a social-psychology perspective, each individual's "self" consists of culturally situated, internalized, competing interests that are constantly negotiating for dominance (Chandler, 2013). These interests are influenced by cultural capital and have cultural relevance and value within specific fields such as science (Chandler, 2013). These fields are socially constructed environments with their own set of practices that operate under their own set of "understood" rules and resources, or doxa (Chandler, 2013). Fields both shape and are shaped by the individuals who make up the field. Science is one example of a field. How individuals are socialized into specific fields at certain points in their development will influence their habitus (Lizardo, 2004). As defined by Bourdieu (1977), habitus is a:

> System of lasting, transposable dispositions which, integrating past experiences, functions at every moment as a matrix of perceptions, appreciations, and actions and makes possible the achievement of infinitely diversified tasks, thanks to analogical transfers of schemes permitting the solution of similarly shaped problems (p. 95).

Figure 2 summarizes the interaction of field, interests, habitus.

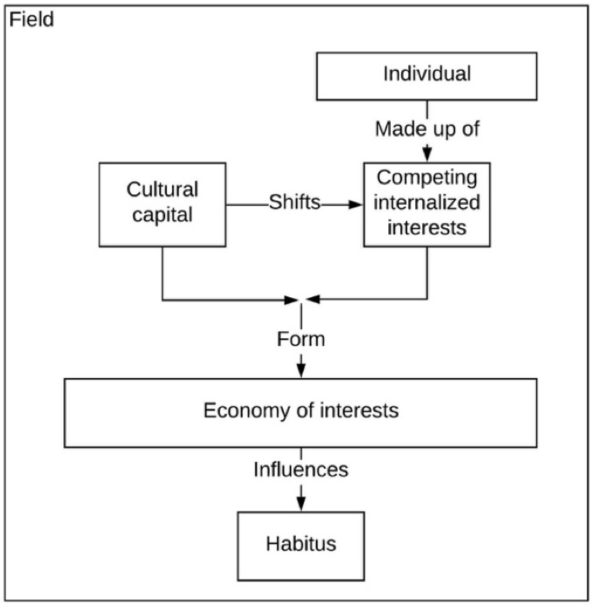

Figure 4: The interaction of field, agent, capital, and habitus. Adapted from Chandler, B. (2013). The subjectivity of habitus. *Journal for the Theory of Social Behaviour*, 43(4), 469-491.

Take for example a family that engages in recycling and makes sustainable living a priority. Children that grow up in this type of household would learn values, strategies, and behaviors about packaging and garbage that would shape their dispositions and future choices about disposing of waste materials.

In addition to being affected by an influx of capital (Chandler, 2013), researchers suggest that habitus is influenced by an individual's past experiences (Chandler, 2013; McClelland, 1990), early childhood experiences (Dumais, 2002), individual actions (McClelland, 1990), observations of others (McClelland, 1990), and their race, ethnicity, and gender (Archer, DeWitt, Osborne, Dillon, Willis, & Wong, 2012).

Habitus influences an individual's habits and behaviors (Bourdieu, 1973), language (Chandler, 2013; Silva, 2016), and beliefs and values (Archer & DeWitt, 2016; Silva, 2016). This includes individuals' beliefs about who they are, what is usual for them, what they do (Archer and DeWitt, 2016), as well as their beliefs about the future in terms of what is possible or acceptable for them (Archer et al., 2012). Individuals acquire new capital as they engage with a social field which then influences and changes their habitus within the field (Chandler, 2013). As an individual acquires new cultural capital, their internal, competing interests begin to renegotiate for dominance which can influence the individual's dispositions and therefore lead to change in their habitus (Chandler, 2013). For example, if student who saw herself as having a future playing softball and spent all of her time on a travel softball team found a new interest in computer coding, she may have to resolve her competing interests. This may lead to a change in her beliefs about herself and her potential career possibilities and eventually her habitus. Figure 3 outlines habitus.

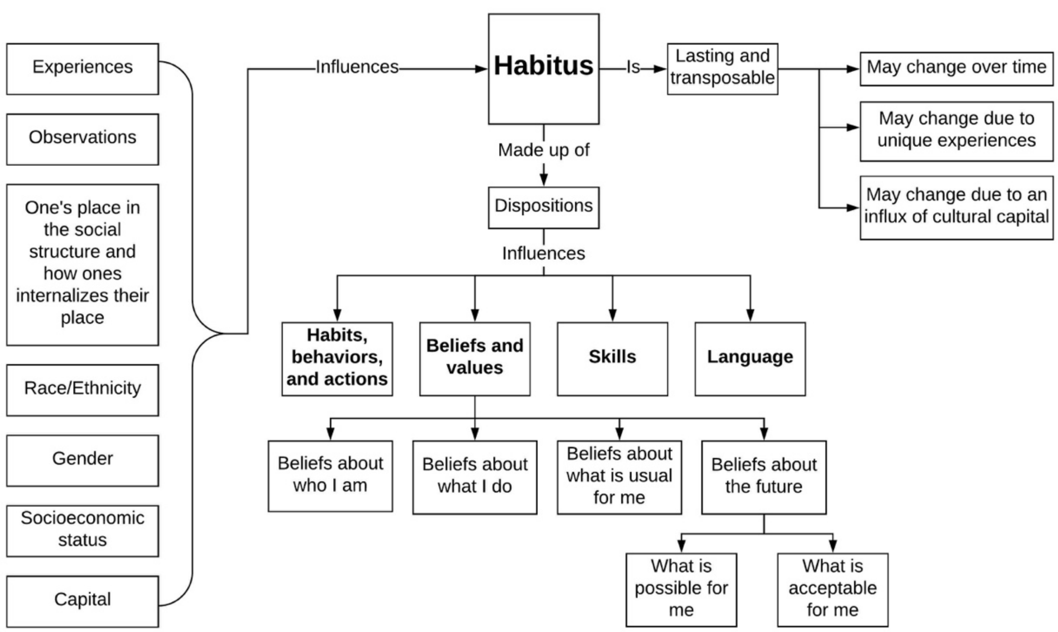

Figure 3: Factors influencing and influenced by habitus.

Family science habitus is described by Archer and her colleagues (2012) as the way a family's economic, social, and cultural capital influences their collective relationship with science and how they identify, value, discuss, and "do" science. Family science habitus suggests that the worldview youth hold in regards to science is a product of their family's beliefs, values, and resources related to science (Archer et al., 2012). A family's habitus prepares youth to receive cultural capital in school (Claussen & Osborne, 2103) and sets youth up for lifelong habits and dispositions (Jones, Corin, Andre, Childers, & Stevens, 2017). As such, the kinds of experiences families engage in together can influence the science interests and career aspirations of youth.

Family Science

Recent studies have found that families play an important role in children's science interests. Children's choices and actions are influenced by their understanding of the world, the demands from their family and social circle, their own skills and past achievements, economic limits and opportunities, location, and other contextual factors (Andre, Whigham, Hendrickson, & Chambers, 1999). Children do not develop science perspectives on their own, but rather form them as part of their family unit. Families have a complex and vital role in developing youths' ideas of what is possible, probable, and desirable for them in terms of science and science careers (Archer et al., 2012).

Parents often encourage interest in science and mathematics from an early age by offering their children opportunities to identify and cultivate their interests through activities such as visits to science museums or buying science kits, by avoiding the expression gender stereotypes related to STEM, and by focusing on accomplishments rather than natural ability in STEM subjects (Wang & Degol, 2013). However, the demographics (capital) of a parent influence the behaviors they engage in, their beliefs, and the resources to which they have access (Davis-Kean, 2005; Wang & Degol, 2013).

Families are often an important first exposure to science (Maltese & Tai, 2010). From early in life, families are a source of knowledge about the environment and shape an individual's understandings of the way things work. Science interests have been found to occur earlier in development when families are the initial source of science interest (Dabney, Chakraverty, & Tai, 2013). Parental attitudes toward science also influence student interest in science. Parents who have a more positive attitude towards science tend to have children who have positive attitudes towards science (Perera, 2014). Parents with positive science attitudes also tend to become more involved in their child's science school work and homework, as well as encourage visits to museums and libraries (Perera, 2014).

Parents play an important role in supporting the development of science identity and career interest through taking their children to informal science centers (Crowley, Callanan, Tenenbaum, & Allen, 2001). Parents who engaged their children in informal science experiences had children with increased science literacy, a greater desire to keep learning about science topics, and an understanding that science was important to them as a family (Crowley et al., 2001). Because youth spend most of their time with their family, informal science experiences for families as a whole are important for developing science interests (Dabney, Tai, & Scott, 2016). Creating programs for youth that includes their family and community may have lifelong, beneficial effects (Dabney, Tai, & Scott, 2015).

Underrepresented families and out-of-school science experiences. Family-based informal programming connects students to science in the community and help them to better understand science, its relevance in their personal life, and increase science interests (Lee & Luykx, 2006). However, leisure studies research shows that African American families tend to spend more time on sports, social events such as dancing and shopping, non-outdoor activities, or fishing (Philipp, 1999; Shinew, Floyd, & Parry, 2004). While studies show they tend not to do so, research shows that African American parents feel it's important for their children to do things like go to museums and zoos even though they didn't feel they fit in there (Phillipp, 1999). Simpson and Parsons (2009) found African American parents want their children to participate in informal science programs that positively impact their children through hands-on, real-world science experiences facilitated by friendly, science enthusiastic educators. In a study of barriers to participation in informal science programs for Latinos, the most important barriers the parents perceived were transportation, cost, language, not being aware of the programs, and issues with safety (Bruyere, Billingsley, & O'Day, 2009). To overcome these barriers, many of the parents expressed a desire to attend the programs as a family rather than send their child alone so that they can ensure their child's safety and because they place a high value on family and would rather attend together. Currently, there is a call for developing family science programs that are more culturally relevant and engaging to more underrepresented students (Bottoms, Ciechanowski, Jones, de la Hoz, & Fonseca, 2017; Fang, McDowell, & Holland, 2006; Valadez & Moineau, 2010).

Family STEM programs. Family engagement with youth is emerging as an important factor in promoting STEM interests and career aspirations (e.g., Archer & DeWitt, 2016; Crowley et al., 2001; Dabney, Chakraverty, & Tai, 2013; Jones, Taylor, & Forrester, 2011; Lee & Luykx, 2006; Maltese & Tai, 2010; Nugent, Barker, Welch, Grandgenett, Wu, & Nelson, 2015; Perera, 2014). However, most interventions in the last several decades have targeted the child as an individual through programs such as STEM camps, classroom interventions, and afterschool clubs and these programs have resulted in limited changes in some fields of STEM such as physical sciences and computing (Musu-Gillette, De Brey, McFarland, Hussar, Sonnenberg, & Wilkinson-Flicker, 2017). There are many studies examining the effectiveness of these types of programs. For a meta-analysis of these programs in the United States, see An

(2013). What has not been well studied are the programs that take a systems approach to building the science interests and career aspirations of youth by working with youth and their families.

The program examined in this study was a museum-based, family STEM program that included career information for parents and youth, supported families in exploring science, and offered new science capital resources. The goal was not only to increase the interest in science and STEM careers of the youth but also parent engagement and interest in science. Including families and parents in the program also helped address several issues related to science interests. Research shows that improving parents' level of education leads to better-educated youth and suggests that a multigenerational intervention is more beneficial than targeting kids alone (Kaushal, 2014). Existing research on out-of-school, family-based science experiences for youth has primarily focused on family science nights in schools (e.g. Harlow, 2012; Ogens, & Padilla, 2012; Sorby, & Schumaker-Chadde, 2007; Sullivan, & Hatton, 2011). This study sought to examine the effects of a year-long, museum-based, family STEM program on the adult participants. For information on the effects of the program on the youth participants, see Ennes et al. (under review).

Research Question

Although the program model in this study was designed to increase the science capital and family habitus of youth with a goal of increasing STEM interests and careers aspirations, examining the effect of the program on the parents who attended with the youth can shed insight into these types of family programs. Few studies have explored the effects of family STEM programs on the parents, however, it is a growing area of research such as studies examining the effects of family science nights on parents (e.g., Yanowitz & Hahs-Vaughn, 2016).

While several studies, such as the ASIPRES study conducted by Archer and her colleagues (see Archer & DeWitt, 2016), have examined the access youth have to science capital, few studies have tried to influence the science career aspirations of youth by increasing their access to science capital and their family's science habitus. Increasing the cultural wealth to which parents have access along with their family science habitus may strengthen their ability to increase and support the science career aspirations of their children. The following research question guided this study:

How does participation in a museum-based, family STEM program aimed at increasing the science capital and family habitus of youth influence the cultural capital and science habitus of the adult participants?

Methods

This paper is part of a larger study examining the science self-efficacy, interest, self-concept, habitus, and capital of youth. The program model, called FAME: Families and Museums Exploring, was developed based on the belief that it is necessary to enhance the science capital and family habitus of families in order to increase the science interests, self-efficacy, and out-of-school STEM experiences of elementary aged youth. The goal is to ultimately lead to an increase in the lifelong STEM interests and career aspirations of youth. The programmatic model used a systems approach to engage the full family (broadly defined by the families themselves) as well as friends and a community of other families in order to leverage the familial and social capital of the participants. The program also offered access to STEM resources, hands-on STEM activities, informal science educators, and STEM mentors. See Figure 4 for the model:

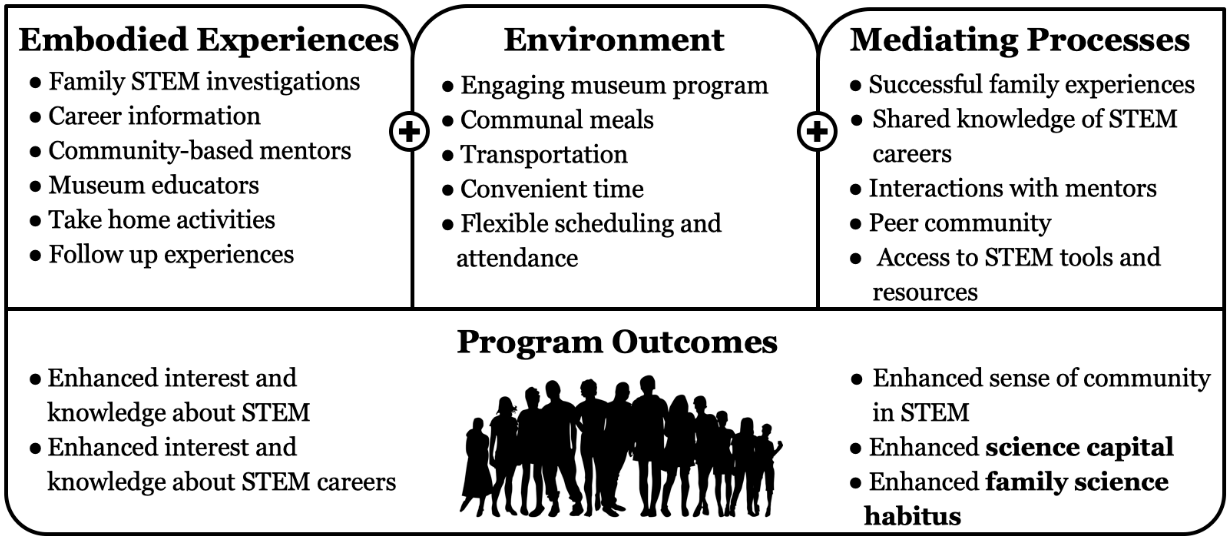

Figure 4: Museum-based, family STEM program model. This figure illustrates the components and outcomes of the program

Each of the three participating museums recruited 20 families from low wealth, underrepresented groups through their partnerships with community organizations who host after-school programs. The museums selected elementary aged youth who expressed an interest, or were nominated based on perceived interest in STEM, but may have limited access to science capital. Once the families were selected, the museums each hosted ten events over the course of one academic year including three joint events for all of the families, one hosted at each museum. The program was intended to be sustained, engaging, and long term (ten months). The individual events over the course of the program included food, engaging STEM activities, career information related to STEM, STEM mentors, embedded technology, and activities for each family to take home to continue learning about the event's topic.

Each day began with the families arriving at their museum to share a communal meal with the goal of building social capital, community, as well as to relieve the parents of the burden of having to plan meals for their children before or after the program. Following the meal, the day's topic would be introduced such as astronomy, mammals, or computer coding.

Each museum was responsible for providing family appropriate, engaging STEM activities related to the day's topic. For example, during the mammals day, families were introduced to local mammals by viewing wildlife camera photos to identify which photos were captured at the location of the program. Participants were expected to engage in the activities together as a family in order to increase their science experiences and familial capital. During the activities, STEM mentors shared information about their careers related to the topic. This was to increase knowledge about careers, the influence science has on college acceptance rates, and other types of careers that use science and might motivate and interest youth (Claussen & Osborne, 2013). Technology was incorporated in each of the programs in various ways, such as an iPad loaded with apps to identify birds or constellations. In order to increase the families' access to science capital, the families each received a kit of materials at the end of each event to take home so they could further engage with the day's topics. These included items such as a circuits kit, books, or the materials to make rock candy.

To assess the impact the program had on the families' science interests, self-efficacy, self-concept, habitus, and capital, the *NextGen Scientist Survey* (Jones, Ennes, Weedfall, Chesnutt, & Cayton, 2018 under review) was given at the first and last events, or at least eight months apart for those families who began the program later. The parent version of the *NextGen Scientist Survey* (Appendix B), had questions related to science interests (n=8), self-concept (n= 3), self-efficacy (n=4), career aspirations (n=1), science capital (n=6), family habitus (n=13), access to science tools (n=21), and science stereotypes (n=9). The post survey included three additional open-ended questions to learn more about the impact of the program on all of the families.

Twelve families, four from each museum, were selected to participate as case studies based on the youth participant's score on the pre-survey. This score was calculated by determining the mean score of each of the following subconstructs from the youth participant's responses: science habitus (n=5), self-efficacy (n=6), science self-concept (n=5), informal science experiences (n=17), and science career aspirations (n=6). Then a final mean was found for the subconstruct mean scores. The youth with the lowest overall scores for each museum were identified and they and their parent were invited to volunteer to participate as a case study participant. Case study families participated in three youth interviews, three adult interviews, a mid-program survey, and were observed interacting during the program at least three times over the course of the intervention. Eleven of the case study families completed both surveys and participated in all three of the interviews. One family withdrew midyear due to personal reasons.

The parent interviews included demographic questions, as well as questions related to science self-efficacy, science self-concept, career and education, their future goals for their child, science exposure as a youth or an adult, science stereotypes, capital, interest, family habitus, perceptions of their child, and perceptions of museums and the program. (Table 1, Appendix C).

Table 1: Questions and topics for parent interviews (n = 116)

Question topic	Initial	Midyear	Final	Total
Science knowledge	1	0	0	1
Self-efficacy	1	0	1	2
Demographics	2	0	0	2
Science self-concept	1	0	2	3
Parent career and education	3	0	0	3
Future goals for their child	2	0	3	5
Science exposure as a youth and adult	3	0	4	7
Science capital	4	0	4	8
Science interests	4	4	2	10
Science stereotypes	4	0	6	10
Family habitus	8	6	5	19
Perceptions of their child	11	1	8	20
Perceptions of the program and museums	4	7	15	26

Participants

Initially, 55 parents and one community mentor who stood in for a parent of one youth participant took the pre-survey. Eleven of these participants were removed from the study because they did not take the post survey. Of those 11, eight were an additional parent of a child participant who had two people initially take the pre-assessment. Three of the adults were removed because their child did not complete the program. This left a total of 44 parents who completed the entire program and all of the assessments. One parent had two children in the program. Of the 44 parent participants who took both the pre and post assessments, the majority were female (Table 2). More than half of the parent participants were African American, with the rest of the group being White, Latinx, or identifying as another race. Most of the parents spoke English at home followed by Spanish and a few parents spoke other languages, such as Hungarian. When asked to describe the area where they live, the majority of the participants indicated they lived in suburban or urban areas and a few indicated they lived in a rural area. (Table 2)

When asked about their education on the pre-assessment, most of the parents had attended as least some college with approximately equal numbers having had some college, a four-year degree, or a graduate degree. When asked about their careers, about a third (32.1%) of the parents said they had a STEM or STEM-related career but 73.2% of the adults said they use science, technology, engineering, or mathematics in their daily work. (Table 2)

Table 2: Parent/guardian demographics

	Frequency	Percent
Gender		
Female	41	93.2
Male	3	6.8
Race		
African American	24	54.5
Latinx	7	15.9
White	9	20.5
Other	4	9.1
Language		
English	36	83.7
Spanish	5	11.6
Other	2	4.7
Home Location		
Urban	18	40.9
Suburban	18	40.9
Rural	8	18.2
Education		
Some high school	3	6.8
Graduated high school	4	9.1
Some college	10	22.7
Two years college	6	13.6
Four or more years college	21	47.7

For the families in the case studies, all the parents were female, nine were African American, one was Latina, and one White. Five participants were married and six of them had two kids, four had three kids, and two had four children. Four of the women had completed some college, three had a four-year degree, and two had master's degrees. Five of the case study parents had a STEM or STEM-related career and eight of them said they use science, technology, engineering, or mathematics in their daily work.

Analyses

Survey. The survey data was entered into a spreadsheet. Most questions were on a five-point Likert scale that ranged from strongly disagree (1) to strongly agree (5). Questions related to science experiences were on a four-point scale, asking how often youth participated in different activities. The choices were "never" (0), "one time" (1), "two to four times" (2), or "five times or more" (3). Interest questions related to different science careers were also on a four point Likert scale, "not at all interested" (0), "not so interested" (1), "interested" (2), or "very interested" (3). Several questions related to science capital were dichotomous with "yes" (1) or "no" (0) as the options.

For the open-ended questions related to careers, the responses were coded using the definitions of STEM careers developed by the National Science Board (NSB) (National Science Board, 2014). The NSB divided careers into STEM, STEM-Related, Technical STEM, or Non-STEM. STEM careers are identified by "at least a bachelor's degree in an S&E [science and engineering] or S&E-related field of study or any college graduate employed in an S&E or S&E-related occupation, regardless of field of degree" (p. 4). STEM-related careers included pre-college teachers in science and engineering, healthcare workers (doctors and nurses), managers in science and engineering fields, etc. A technical STEM career was identified by the need for schooling beyond high school that may result in an associate's degree, technical certification, or other professional license. These careers "combine conventional literacy with technical expertise" (National Science Board, 2014, p. 4). STEM, STEM-Related, and Technical STEM careers were collapsed into the category "STEM" (1) whereas all other positions were coded as "NonSTEM" (0).

The survey data were analyzed using IBM SPSS 24. Changes from pre to post for each item were calculated using the Wilcoxon Signed Rank Test. Other changes were analyzed using a t-test.

Interviews. For the case study interviews, each interview was transcribed and read for themes. The interviews were coded using a priori codes developed based on the types of cultural capital and family science habitus. The interviews and open-ended questions on the final survey were independently coded by two researchers. Both researchers were very familiar with the study and had helped collect data. The second coder was provided with a codebook with the code, definition, and an example for each code. The two coders independently coded all three open ended questions on the final survey to establish interrater agreement. The interrater agreement was found to be .907 (McHugh, 2012). The coders discussed any discrepancies and came to a consensus. The resulting codes were: "science capital and habitus," "social capital," "familial capital," "navigational capital," "aspirational capital," and "linguistic capital." The codebook can be found in Appendix D.

Results

In the section that follows the experiences of two case study parents are described as illustrative cases, the results of the case studies and the parent information from the surveys are presented. This cross-case description will examine different themes that arose during the analysis (Yin, 2014). Pseudonyms are used throughout the results.

Cases of Childhood Science Capital

Ayanna. Two parents represented a dichotomy in their access to science capital as a child. Ayanna is an African American, single parent of three children. She is one of six children and grew up in the Northeast. When talking about her childhood, Ayanna reported that she had engineers in the family and receive gifts of science materials as a child: “for Christmas and birthdays, we'd get science kits. I remember making globs and glues and having to make predictions. We made a lot of messes. We made lots of experiments and [had] books” (initial interview). She remembers cooking as a family, taking nature walks, talking about the weather and birds, as well as visiting a museum with large statues. In spite of her access to science capital, she did not feel confident in her science skills in school. She remembers science being difficult:

> It just seemed like a lot of ‘sit and get,’ not too many hands-on things… I just remember always wanting to get to middle and high school because I would hear my older siblings talk about the different things that they did in science, but that wasn’t always the case growing up. And so, I didn’t really get the hands-on experience, which is why I had never really got into science (final interview).

As a child, Ayanna wanted to be a teacher and felt supported by her family in this goal. She hated school as a child and “couldn’t care less because I thought my teachers couldn’t care less” (initial interview). She earned a degree in education because she wanted to make school better for kids and went to work for Teach for America. She initially planned to get a master’s degree in education but when the state where she currently lives discontinued master’s pay, she decided not to go into more debt. She enjoyed teaching third grade but eventually moved to kindergarten because there was “too much testing and stress” for the older students (initial interview).

As an elementary school teacher, Ayanna discussed the difficulties she faced in engaging her students in science. She felt science was “hit or miss” within the curriculum and believed it could be covered by “reading a book or something quick and simple just a few times a week” (final interview). When asked if she was interested in science and engineering prior to beginning of the program, Ayanna said “Not so much, I don't think I developed the love I want [my children] to have. It’s not a priority. It's interesting but not enough to wonder more” (initial interview).

Ayanna said she joined the program because she wanted her daughter to have a chance to develop an interest in science, something she never had. She also wanted to spend more time as a family and help her children see the interdisciplinary side of science. Ayanna felt her daughter was more of a math person because “she can start to solve problems and it's not cut and dry. You can figure out what went wrong and you can see why you're successful and she is exposed to it more everyday than science” (initial interview). However, Ayanna thought her daughter might consider a career in STEM if she had a better understanding of what careers use science and mathematics.

Initially, Ayanna said her family did not do much related to science in their free time. She also indicated she didn’t talk with her daughter about science as much as she may have with her son.

> Before she wasn’t interested in science. She wanted to be a dentist. She liked math but wasn’t interested in science. I hadn’t taken time to break [what science is] down as much

as the program has and it has given me a learning moment as well... I like that she's is more interested than before so I want to keep that going. Before... I've gotten [my son] things for science and I didn't do it for her. I have been questioning myself as to whether it was because he was a boy and she might not be interested. So [now] she's getting science kits as well (final interview).

She went on to discuss types of conversations she was now having with her daughter such as digesting what they learned during the day's program, predicting the weather, making hypotheses, and talking about what constitutes science and science careers.

Ayanna also indicated the she had seen changes in the way they talked about science as a family.

> Even though it was for [my daughter], the other kids were able to explore and experiment and get the same type of experiences, which is nice. And so that creates more conversations beyond her and I. So, then you get to hear what the kids are thinking if you sit back and listen to the different perspectives… and especially with the different age levels, and helping one another problem solve (final interview).

They were also doing more science related activities as a family outside of the program: "We do nature walks and go to the park and we cook together, make weather predictions definitely, we love doing that, but we need to do more experiments" (final interview). Ayanna also indicated they were visiting more museums and would continue this in the future. She had even begun sharing her new knowledge about science by gifting science kits and talking with other parents about what they had been doing. Her daughter had shared the take home materials with her friends and the parents called Ayanna to find out more about them and where they could get their own sets for their daughters. She was pleased to be able to share her knowledge with the other parents.

When asked whether the program had changed her interest in science, Ayanna said,

> Oh yes, in general, I am [more interested]. I would like to learn more and do some of the STEM activities that we have. And the coding is really cool... I signed up for a coding elective [in my job] because we're starting now in kindergarten, and they needed some volunteers and I signed up for the gardening. So, I'll be teaching both of those electives. But I'll be actually learning myself as I teach the kids. So, it'll be a really cool experience (final interview).

She went on to discuss how she realized she needed to do more science in her classroom. Ayanna mentioned a conversation with a colleague where she suggested they include science for the morning work to make sure it is included in the class every day.

> Now I see the importance of doing [science] every day and the impact just from having it every few Saturdays a month, every couple of months, how it changes the way that my daughter thinks, when I know she didn't think of it before, as well as myself. So really, kids starting young and getting them to think about science (final interview).

When asked to reflect on her own life and what things may have encouraged her to pursue a degree in STEM, Ayanna mentioned her difficulties with science in school and how it failed to spark her interest.

> I think if I had more access and more knowledge, more experience, more understanding of the different ways science is used and how fun it is [I would have majored in science]. I don't think I saw the joy in science. I just looked at vocabulary words, and I thought you had to go to school for twenty years to do it, and so I didn't understand the ins and

> outs and the different careers… Even in college, it was just that we were learning about astronomy and things that seemed like vocabulary word after vocabulary word and it was just, it wasn't a good time and now I am thinking of the different ways it could have been taught to spark my interest more (final interview).

Chloe. Unlike Ayanna, Chloe came from a family with little science capital. Chloe is an African American, single mother of three. She grew up in the rural part of a southeastern state. Chloe doesn't remember having any science-related toys, activities, or books in her home as a child. She knew people who worked in financial fields but no one in science. She said she did not like science in school except chemistry because it involved a lot of mathematics.

> The only thing I remember about science was my chemistry class, the periodic table. I didn't really like doing science experiments. I think we dissected a frog, I didn't even like that... I didn't have that much exposure to science... We played outside a lot, because video games were rare in my day. There weren't activities like going to the science museums for weekend activity (final interview).

As a child, Chloe wanted to be an accountant. She felt pushed into that career because she was good at it.

> I grew up in a rural part of the state. There weren't a lot of resources at my school. There was only one high school, everyone knew each other, and you weren't exposed to a lot. And so, I was really pushed into business because that was my strength and it was like science and everything else was on the back burner (final interview).

Chloe initially said she did not find science or engineering interesting and would not describe herself as a science person. She reported that she did not take her children to museums or do other science-related activities. However, she chose to join the program because she knows both her son and daughter have a strong interest in STEM fields. Her daughter wants to be a in the medical field, maybe a dentist, and her older son is interested in engineering. She wanted to broaden their horizons about what careers are in STEM.

> [My son] has always been interested in engineering and technology, and I want to foster that. And [my daughter] actually has, since she was like 3, she wanted to be a scientist. Then it changed to a doctor, then a dentist, but it's always been something scientific. When I heard about the program, I really wanted them to be involved just to expose them to more scientific activities. Especially since I wasn't one for science. I wanted to let them be exposed to it. Interestingly enough, I am intrigued by a lot of the stuff I have learned (final interview).

Even though she joined the program for her children, she felt it had a big impact on her as well:

> It definitely opened our world to science. I actually developed a "like" relationship with science. Not quite with the "love" thing yet. But the exposure has really...I mean, we have conversations about space. At night, we're looking at the moon to see if we know if it's a full or half moon, stuff like that. To see if we can find the big dipper, the north star. With every activity that we've had, it's really opened our world up to the world around us (final interview).

Chloe said participating really changed her attitude towards science.

> Yeah, it's definitely given me a 'like' relationship with science and I'm actually open to learning new things about science instead of saying 'I don't like this subject, so I'm not going to like any of it.' I don't have that attitude anymore about science (final interview).

Chloe talked about how they are more likely to talk about science as a family or visit more museums. She said she even changed what she did for her daughter's birthday based on the program:

> Yes. I told them for [her] birthday- and we've never done this but I know it's because of the influence that the program has had- I went online to look at these science experiments that she could do with her friends. We tried them out. We did the lava lamp, that is really cool. I love doing that. And we made snot. I was hoping the girls would get a kick out of that since most of them have brothers. It was more like slime (final interview).

The events she participated in even changed her hobbies at home. After participating in a program on bird banding:

> We took the bird feeder home and hung it. I did bird watching before now, but now I'm really interested in it, now that we did the whole process of bird banding. I've really enjoyed that. To see the birds up close, how beautiful they are. The Venus flytraps, I do want to try that again. I'm not a plant person, but those particular plants caught my eye. So yes. I'm even thinking about growing a garden. Stay tuned. *laughs* (final interview).
> Chloe also enjoyed meeting new parents with similar goals.
> I like this because it's a different setting, a different environment. So, we met different people. And it was people who were kind of like minded and seemed inquisitive and wanted to learn more, had something to contribute so that was fun (final interview).

She ended the year saying "it was nice to meet some of the other families. I actually have some of their numbers and we're going to stay in touch" (final interview). Chloe realized she not only made a larger social network of people interested in science, but that she also had people in her family who could support her children's interests in science. When asked at the beginning of the year, Chloe did not think she had anyone in her family who worked in STEM outside of a few accountants. At the end of the year she asked if the STEM field includes medical careers. When she was told yes, she replied: “I have a cousin that’s a doctor, she’s my age. That’s why I’m really hoping that [my daughter] wants to go down that route. She’s the only cousin that I know of that’s in a science-related field. My other cousin is a registered nurse” (final interview).

The parents were each asked whether they felt gender made a difference in a child’s interest in STEM. Chloe initially said yes. At the end of the year her answer had changed. When she was asked what changed she said, “my daughter is interested in science and had she not been, I probably would still feel that way. I have this daughter that’s interested in science, so what do I do? It’s been a great learning experience” (final interview).

These two stories exemplify the type of change that took place with parents who did not have an interest in science or felt like they did not have the ability to help support their children’s interest in science. There were other parents who had high science capital and worked in science, such as Tamika, but she was atypical of the other parents. She grew up in a family with high science capital who encouraged her to pursue a science career by placing her in a STEM program in middle and high school. She never completed a college degree but is now a lab technician and has a son with a strong interest in science however he does not see her work as being in a STEM field. To further examine how the program influenced the cultural capital and science family habitus of the families in this program, we will examine each aspect of capital and habitus below. The data includes quantitative and qualitative survey data from the 44 parents in the program as well as qualitative data from the 11 case study parents.

Cultural Capital

As noted earlier, cultural capital includes science, social, familial, aspirational, navigational, linguistic, and resistant capital. Results for science, social, familial, and aspirational capital are described in the sections that follow. These data come from the 11 case study parents as well as the open ended questions that all 44 parents answered at the end of the year.

Science capital: On the NextGen Scientist Survey, all the parents were asked four questions about their science capital as a child (Table 3). Participants were asked questions about science-related materials, social resources, and science experiences as a child. When asked whether they had access to science toys and tools as a child, 23.3% of the parents indicated they did not. When asked if they knew anyone, as a child, who worked in a STEM field, almost half (46.5%) reported they did not know anyone in a STEM field. More than a third (38.6%) of the parents said they did not participate in a science fair or club and 65.9% said they did not participate in scouting or 4-H as a child.

Table 3: Frequency of parents' reported access to informal science as a child

When you were a child	n	Yes	No
Did you have access to science toys and tools	43	76.7	23.3
Did you know anyone who worked in STEM	41	53.5	46.5
Did you do science fair/club?	44	61.4	38.6
Did you do scouts or 4-H?	44	31.4	65.9

The parents were also asked to think back to what they wanted as a career when they were a child. This was compared to their current position. Table 4.

Table 4: Parent career aspirations compared to current career

	N	STEM Career	NonSTEM Career
What did you want to be when you grew up?	42	57.1	42.9
What is your current job?	42	35.7	64.3

Nearly half (46.5%) of the parents reported that they did not know anyone who had a STEM career as a child. Yet more than half (57.1%) of them wanted a STEM career when they grew up. However, only about a third (35.7%) of the parents reported that they currently work in a STEM, STEM-Related, or Technical STEM career. Even though only 35.7% of the participants indicated they have a STEM career, 75% initially said they use STEM in their daily work.

When asked at the beginning of the program if they knew anyone who worked in a STEM field, less than a quarter of the parents knew someone in their family (23.8%) or anyone at all who worked in a STEM field (22.7%). However, by the end of the program, a Wilcoxon signed-rank test found the number of people reporting that they knew anyone who worked in STEM had significantly increased (z = -2.65, p = .008) with more than three quarters (76.7%) of the parents indicating they now knew someone who worked in STEM. Table 5.

Table 5: Parent' reported access to science pre and post program

	Pre-Test			Post Test				
	n	Yes	No	n	Yes	No	z	*p*
Do you know anyone now who works in STEM	44	77.3	22.7	44	93.2	6.8	-2.65	.008*
Do you know anyone now with STEM hobbies?	44	68.2	31.8	43	76.7	23.3	-1.00	.315
Does anyone in your family work in STEM?	42	76.2	23.8	43	86.0	14.0	-1.41	.157

Note: * $p < .01$.

In order to increase the science capital of the families participating in the program each week, families were given science materials to be used at home, they had access to mentors, and were provided new experiences in science. Ayanna believed this was an important part of developing an interest in science. She said her career path may have been different if she had known more about the hands-on side of science and the variety of careers that use science.

One of the components of science capital is knowledge of science. On the end of year survey, 11 parents indicated they had a greater knowledge of science and its influence on their families. Ten parents said they learned new information about science in general and five had more awareness of the role science plays in everyday life. Eight parents said they had a greater knowledge of science careers and hobbies. One Latina mother, Sofia, who was part of the larger study, discussed the knowledge she gained to help guide her daughter's career decisions,

> This was a great opportunity for my child to grow in the knowledge of science and the many possibilities available. It helped me to have more information to guide my daughter in her interest in animal science as she wants to be a veterinarian (final survey).

Some families still indicated on the post survey that they struggled to understand what kinds of activities are "science" so they could do them at home. One case study mother, Risa, said "we don't know what to do. Not being exposed to these activities, it's basically not knowing" (initial interview). However, another, Kelly, indicated that the resources they received as part of the program "is keeping the learning going" (final survey).

Social capital. When examining parent responses for examples of changes in social capital, several patterns emerged. Two of the case study parents indicated they initially enrolled in the program because they wanted their child to have an opportunity to socialize with other children who like science. Like Chloe, several parents reported on the end of year survey that they were glad to have met other families who were interested in science. Four parents said they, or their child, had developed a community of people who liked science. One White mother, Kelly, said the program was "an opportunity [for her son] to see that other friends his age are interested in science as he is" (final survey). This was echoed by Brittany when she told us "my son has enjoyed meeting other children that have an interest in science" (final survey). Chloe said she was already leveraging the social network to identify new program opportunities for her children.

> There might be other activities that we don't know about through other places. The university offers [a STEM program] we didn't know about until we were a part of the science club. It was someone at the [program] who told us about it (final interview).

Like Ayanna, other mothers indicated they were sharing new information with their social circles. Case study mother Zoe said "I share a lot of information with my friends and family" (final interview).

Familial capital. Familial capital is considered an extension of social capital. One mother, Claire, felt the program achieved both social goals: "it was a wonderful opportunity for all of us to learn together and network with other families" (final survey). Another African American mother, Heather, said involvement in the program "helped us bond and learn new things together. I've learned my child is very knowledgeable on things I never knew. It exposed us to new things and made learning fun as a family" (final survey). For many of the parents, this program was an opportunity to spend more time as a family as seen by Viola's comment: "She loves science and it is an extracurricular activity that gives us something to do over the weekend, together" (final survey). Some of the parents extended their familial capital through non-related members. One African American mother told the educators running their program that their family referred to them as their "Vanilla Aunties" when discussing the program at home.

Aspirational capital. Changes to the parents' aspirational capital influenced not only their aspirations for their children but also for themselves. Three parents aspired to go back to school to pursue degrees in science after participating in the program. One father had already enrolled in a science program and two mothers were considering going back for a new degree. One of the mothers, Tamika, said the STEM professionals in the program really made her feel she could go to college for a degree in medical ethics or something related to the biomedical field:

> It's made it easier to see if I can try again to go back to school... Seeing the people that were doing the instruction and the people that helped it and giving some background about what they were doing. Listening to them talk about what they do and the types of jobs that they may do, and what they do when they do their job and, main thing, knowing it was all local. Different parts of the state but it's all still local (final interview).

On the end of year survey, two parents explicitly said they knew how to better support their child's interest in science. According to Serena, "my son is a real scientist type and this year was a huge support for him and for us to know new places, opportunities, topics, what we could have known without the science club" (final survey). An additional two parents said they had a better understanding of what careers were available in science so they could encourage their child. One African American mother, Olivia, said,

> My family has a deeper appreciation for science related experiences and understand the impact these experiences will have on our son's future. We are increasing dialogue about

science related careers and I feel strongly that he will pursue a career in STEM (final survey).

Linguistic capital. Linguistic capital represents the languages, including the language related to science, that one possesses. Chloe said,

> This program has exposed us to the world of science in ways we would not have explored ourselves. We talk about earth, how to make the world a better place and have plans to visit zoos, aquariums, and museums more often (final survey).

Other parents reported changing how they spoke with their family about science at home. Claire said this of the program, "it did help us be even more intentional about how much we talked about science at home" (final survey). Serena, a mother who recently immigrated to the United States said "we talk more about science because the [program] was the best [part] of our last year" (final survey). One Latina mother, Camila, said it even impacted the way her extended family spoke about science. "I invited [my nephews] a couple of times and they were very impressed, excited, knowing more about science. They are now more interested in science books and talk more about this topic" (final survey).

One parent, Elizabeth, indicated that she noticed a change in how her daughter spoke about science. "I hear my daughter talk to her friends that she goes with to explain what she is doing and how things work. She also explains things to her family upon return after activities. She uses more science vocabulary too" (final survey).

Navigational capital. When examining the instances where the parents indicated they had changes in their ability to navigate resources surrounding STEM, several parents indicated they were now taking steps to find new experiences and opportunities for their children to continue engaging in STEM. Brittany said "it has made me explore other opportunities to integrate science into my children's routines” (final survey). Another parent, Pat, said the program “has encourage me to continue to find exciting programs as such to expose my child to science, technology, etc” (final survey). An increase in navigational capital was also seen in the earlier quote from Serena that she now had a better understanding of new resources to support her son’s interest in science thanks to participation in the program. Chloe also spoke of her increase in navigational capital through the network of people she met in the program.

Family Science Habitus

Family science habitus influences a family’s beliefs about who they are and what they do related to science. The *NextGen Scientist Survey* asked parents and guardians how often they participate in a series of science related activities. (Table 6) Participants could select from a four point Likert scale of “never” (0), “1 time” (1), “2-4 times” (2), or “5 or more times” (3).

Table 6: Parent responses for how often they participate in science related activities (pre and post).

	Pre	Post					
How many times in the last year have you:[a]	M (SD)	M (SD)	ΔM (SD)[b]	95% CI	t	df	*p*
Built or taken things apart	0.82 (1.00)	0.73 (0.92)	-.09 (0.98)	[-.39, .21]	-0.61	43	0.54
Gone hunting or fishing	0.89 (1.04)	0.89 (1.08)	.00 (0.96)	[-.29, .29]	0.00	43	1.00
Used binoculars or a telescope	0.89 (1.04)	1.25 (0.92)	.36 (1.33)	[-.04, 0.77]	1.81	43	0.08
Planted a garden	1.07 (0.96)	1.36 (1.14)	.30 (1.19)	[-.06, 0.67]	1.67	42	0.10
Read a book about science	1.77 (0.99)	1.80 (0.98)	.02 (1.29)	[-.37, .41]	0.12	43	0.91
Read a map	1.79 (1.17)	1.89 (1.17)	.09 (1.21)	[-.28, .47]	0.50	42	0.62
Gone to a zoo, aquarium, museum, or planetarium	1.89 (0.87)	2.41 (0.98)	0.52 (1.05)	[.21, 0.84]	3.32	43	0.00*
Gone online to learn about science	1.98 (1.02)	2.11 (0.95)	.14 (1.09)	[-.20, .47]	0.83	43	0.41
Gone on a nature walk	2.14 (0.85)	2.14 (0.98)	.00 (0.92)	[-.28, .28]	0.00	43	1.00
Talked about science with others	2.16 (0.87)	2.61 (0.62)	.44 (0.83)	[.19, .70]	3.51	42	0.00*
Used a thermometer	2.21 (0.89)	2.16 (0.92)	-.07 (1.00)	[-.38, .24]	-0.46	41	0.65
Watched science tv shows	2.32 (0.96)	2.32 (0.77)	.00 (1.10)	[-.33, .33]	0.00	43	1.00
Used a ruler	2.39 (0.87)	2.47 (0.83)	.09 (1.17)	[-.27, .45]	0.52	42	0.61

Note: [a] Items were on a 4 point Likert scale: “never” (0), “1 time” (1), “2-4 times” (2), or “5 or more times” (3). [b] Mean difference from pre to post. * $p < .01$

Of the 13 science activities listed, two changed significantly from pre to post. This included how often parents reported they went to a zoo, aquarium, museum, or planetarium ($t(43) = 3.32$, $p = .002$) and how often they talked with others about science ($t(42) = 3.51$, $p = .001$). On the final survey, ten parents said they were engaging in more science experiences with their families.

Sofia brought her children to the program and said it changed the activities their family’s habitus:

My children now can tell what science is all about and the different types of science. They are more interested in becoming [a scientist]. They want to explore the world, they look for rocks, plants, animals and tried to find more about it. We go to explore at museum, parks, zoos, beach, etc. They ask to buy tools to use that are science related like binoculars, bug catching, etc (final survey).

Olivia also talked about how she had to change their family's habitus.

I have increased the priority to involve my son in STEM activities as much as we can. He is such an athlete but we have shifted or priorities to have a balance between STEM and sports because he loves both (final survey).

This was similar to the change Claire had when thinking about her sons.

Our other son also loved coming to these events. It was actually really good for him/us because we often think of our other son as being the real science/math kid and him into reading and sports. But he is absolutely just as interested in science. Thanks for helping us see that (final survey).

The parents were asked whether they had spoken with their family about science in the last week (Table 7).

Table 7: Change in parent responses to whether they speak with their family about science pre to post.

	Pre	Post					
	M (SD)	M (SD)	ΔM (SD)	95% CI	t	df	*p*
In the last week have you talked with your family about science?	0.70 (.46)	0.84 (.37)	.14 (.46)	[0, .28]	1.96	43	.57

Note: Item was scored 0 for "no" and 1 for "yes".

While there was not a statistically significant change in the number of parents who said yes from pre to post, nine parents indicated that they do spend more time talking about science as a family. Camila said “This program had a huge impact for my family. I have four children ages 12, 8, 6, and 4 years and they learned new things about science and I did too. Now we have new topics of conversation at home” (final survey). Another Latina mother, Luciana, said her “kids like to ask more questions about science and read the news about natural events in the world” (final survey). This was also seen in the comments from Juan about family conversations regarding how science is part of their everyday life.

> The program has helped me to bring up things in everyday life this is impacted by science. I now let them measure and mix things to cook so they can see the outcome. I can appreciate the program exposing kids to different aspects of science (final survey).

When asked why they chose to join the program, most of the case study mothers said they valued the program because their child had a previous interest in science or because they wanted their child to have an interest in science. Ayanna said her daughter was “not really a science buff but I hoped if she has an opportunity to explore science at her level it might pique her interests” (initial interview). Two of the parents also wanted to increase their own science interest. Another mother, Risa, said she joined “just to find out if [my daughter] really likes this and to grow in science. I teach pre-k and want to learn more I can take this back to my class” (final interview).

When they began, most of the mothers were already interested in science, however, the few who were not had changes in their beliefs. This can be seen in Chloe’s comments about being “more in ‘like’ with science” and Ayanna’s about being interested enough to learn coding to teach at her school. This was reflected when all of the parents were asked whether they felt their family saw them as a science person. When asked on the pretest, 25% of the parents said yes and there was a significant increase to 38% on the post test, $t(44) = 2.423$, $p = .022$. One father indicated that this “gives me the motivation to be accurate on giving an answer [to questions] that my children may ask on science and technology” (final survey). Another mother, Kennedy, said “I realized I was missing opportunities to teach my child about science. I've corrected that” (final survey).

Limitations

One of the limitations of this study is the small sample size that was related to the nature of the program and the number of interviews conducted. While the participants were recruited from communities of low wealth, the educational background of the parents in this study may not be representative of those who come from a low socioeconomic community. All of the responses in this study are self-reported data must be viewed in this context. Also, as culture plays an important role in cultural capital and family habitus, care should be taken when generalizing these results beyond the scope of these cases.

Discussion

This paper described the effects of a year-long family STEM program on the cultural capital and family science habitus of the parent participants. The program was specifically designed to make it easy for families to participate through efforts to remove potential barriers. The interviews showed that the program was effective in positively influencing the capital and habitus of the parent participants.

Cultural Capital

Science capital. According to results from the survey, many of the parents had an interest in a STEM career as a youth but lacked role models to encourage them to pursue them. More than half (57.1%) of the participants wanted a STEM career when they grew up. However, only about a third (35.7%) of the parents reported working in a STEM, STEM-Related, or

Technical STEM career. Nearly half (46.5%) of the parents reported that they did not know anyone who had a STEM career as a child. This lack of role models may have led to fewer of the participants pursuing careers in STEM despite their interest (Clark Blickenstaff, 2005; Sonnert, 2009).

Even as adults, 22.7% of the parents initially said they did not know anyone with a career in a STEM field. However, that changed significantly from the presurvey to the postsurvey. This may be a result of a better understanding of what constitutes STEM as several parents initially expressed confusion about what is considered a STEM job. For example, Elena, on the end of the year interview explained that she had initially reported that, as a child, no one in her family had a STEM job but later realized that nursing was in the STEM fields. When asked if anyone in her family had a STEM job as a child on the post interview she replied,

> I will say yes, but as far as knowing what they did, no I didn't know what they did, no one familiar or had an experience with. My mom was a nurse, but you don't really know what's related to science (final interview).

Additionally, the increase in knowing people in STEM may be due to the opportunities to meet STEM professionals during the program. This can be seen in Tamika's comments about the importance of meeting local STEM professionals.

An additional area for improving the science capital of these families lies in their knowledge of people with STEM hobbies. A recent study of adult science hobbyists found that knowing someone with STEM hobbies is important for building early science interest (Corin, Jones, Andre, & Childers, 2018). In the present study, 31.8% of the parents initially said they did not know anyone who engaged in science hobbies, and providing access to adults in STEM careers is one way to help build family science capital and habitus. Access to role models was seen by the parents as being an important part of science career interests as Ayanna indicated when she discussed how knowing more people in science may have changed her career path. Role models can play a fundamental role in helping an individual feel relatedness, or connected to others and as if they belong (Deci & Ryan, 2000). This has been shown in other theories such as self-determination theory that suggests feeling relatedness is important for an individual to internalize a desire to pursue a particular path (Deci & Ryan, 2000).

Several of the parents felt that they had greater knowledge of ways to support their child's interest in STEM and STEM careers. They indicated they had learned new information about their children, such as the mothers who saw their sons as "sports kids" but realized they were also "science kids". They also had greater knowledge of how to support their career aspirations through opportunities to engage in activities within the community and other activities.

Social capital. Several parents in this study discussed their desire to build a network of families that also enjoyed science, or their social capital (Bourdieu, 1986; Yosso, 2005), for themselves as well as for their children. This was achieved by several parents within the study. This form of capital is important to help parents understand and negotiate the field of science which may be unfamiliar to them (Yosso, 2005). Parents in the study indicated that they had developed new connections with others. Ayanna discussed the new relationships she was building as part of the program. "A lot of the families are from [the school where I teach] and it has really given me an opportunity to get to know them and talk on a personal level rather than a professional level" (midyear interview). There was also evidence that parents extended their social network to include museum educators who were referred to as the "vanilla aunties."

Familial capital. The program also helped families spend more time together engaging in science activities, as Heather described when she discussed family bonding and learning new things about one another. Other researchers have shown that parents are early sources of science interests and often act as gatekeepers for out-of-school science activities (Dabney, Chakraverty, & Tai, 2013). Increasing the opportunities for families to engage with one another as well as other families in pursuit of science experiences and opportunities can potentially build science capital and ultimately career aspirations for youth.

Aspirational capital. The results of this study indicate that the aspirations of the parents changed both for themselves as well as for their children and this suggested enhanced aspirational capital. Three parents indicated that, as a result of their participation in this program, they were either currently pursuing a STEM degree or had plans to do so in the future. Participation in the program helped them to see that they were capable of doing so. For Ayanna, the teacher who is learning to code to teach her students it was due to meeting local STEM professionals who were representative of something she could achieve. This suggests that in addition to being important for youth career aspirations (Clark Blickenstaff, 2005; Sonnert, 2009), role models may be instrumental in helping more adults pursue STEM degrees.

Additionally, the parents reported they gained new knowledge about their children's interests as well as how to support them in those interests. These includes the parents who found that their children had a greater interest than expected such as the "sports kids." This also includes parents like Olivia who is increasing her dialogs about STEM careers with her son. This type of support is very important in increasing the STEM career aspirations of youth, particularly for underrepresented groups (Hernandez et al., 2016; Moore, 2006).

Linguistic capital. Linguistic capital is related to the types and number of languages of which an individual is capable (Yosso, 2005). Science has its own particular language and vocabulary that is required for participation (Claussen & Osborne, 2013). One parent within this study reported that her child had changed the way she talked about science and was beginning to use more science related vocabulary with her friends. Other parents discussed the way they changed the way and amount they spoke about science with their child and as a family. Command of the language of science is necessary to pursue science careers (Claussen & Osborne, 2013) and this is one area that is not typically explicitly addressed with this type of program. However, it would greatly support the science capital of families and may lead to greater science career aspirations. Helping parents have effective conversations with their children about science is one way family programs can help increase support for youth science interests. Chloe was a great example when she said she changed the way she spoke about science with her children and quit saying she hated it. How parents talk about science and science careers can influence their children's beliefs about it as well (Keller & Whiston, 2008; Perera, 2014).

The participants in this study also indicated that they spent more time talking with others about science. The parents were talking more about science with their immediate families as well as with other friends and families. They spend more time talking about how science is related to their everyday life. This is particularly important as youth tend to have a greater interest in STEM when they see the relevance (Lee & Luykx, 2006).

Navigational capital. Navigational capital allows an individual to successfully negotiate institutions such as school, applying for jobs or college, and others (Yosso, 2005). While information on applying for scholarships and how to prepare their children for college was addressed at the end of the year celebration, including it throughout the year may have done more to build navigational capital. Although the on-going programs talked about careers and provided community mentors related to different careers, the process of financing and applying for college was not addressed until the end. One parent, Zoe, said she would have liked to have "learned about, for the parents getting scholarships for older kids for science programs" (final interview). So, there was a need for more of that type of intervention, as this is another type of capital that may form a barrier to pursuing STEM careers (Hernandez et al., 2016).

However, several parents made comments suggesting they had an increase in their navigational capital as they were already finding, or in the process of finding new resources to support their child's interest in science. These parents felt encouraged to look for resources that they did not know existed prior to the program. Knowledge of resources is an important part of navigational capital.

Navigational capital also allows students to negotiate unsupportive or hostile institutions (Yosso, 2009). There is need for a long-term examination of how these youth fare in the future after leaving this supportive environment for potentially unsupportive environments. One could speculate that by building family capital, youth and parents may have developed an internal perception of their abilities and support, but further research is needed to explore whether or not the program built navigational skills.

Family Science Habitus

A family's habitus influences their dispositions about who they are, what they do, and what they believe (Archer & DeWitt, 2016). This program attempted to increase the family science habitus of its participants through an increase in experiences, access to mentors, and by building a community of like-minded families. The role families play in helping youth develop ideas of what they are capable of and interested in regarding science and science careers is complex but vital (Archer et al., 2012).

The results showed an increase in two of the science-based activities in which participants reported participating. By the end of the year, parents indicated a significant increase in the number of times they visited a zoo, aquarium, museum, or planetarium. This is an important part of family science habitus as these places offer opportunities for youth to develop greater science literacy, the desire to continue learning about science topics, and knowledge that science was important to their family (Crowley et al., 2001). Parents are able to support the development of science identity and career interest through taking their children to informal science centers (Crowley et al., 2001) and these experiences increase the likelihood that the youth will choose STEM fields in college (Dabney et al., 2012).

The participants also indicated that they changed how they prioritized their children's activities after having participated in the program. The two mothers who learned they needed to balance sports with STEM are a good example, as well as the parents who began finding new ways for their children to engage in STEM outside of school. Another example is the two case study mothers who realized they had previously believed their sons to be more interested in science than their daughters. It is important that parents encourage science interest by giving their children opportunities to grow their interests through out-of-school science experiences such as trips to science museums or giving them science kits and by avoiding the expression gender stereotypes related to STEM (Wang & Degol, 2013).

How parents feel about science has major impacts on their family science habitus as well as their child's science interests. Parents who have a more positive attitude towards science can produce youth who have positive attitudes towards science (Perera, 2014). While many parents indicated they were initially interested in science when beginning the program, several of the case study mothers who were not, found a new interest during the program. This change in interest may have changed how the parents believed their family viewed them as a science person. There was a significant increase in the number of people who felt their families saw them as a science person. This may have a beneficial effect on their children.

Future Areas for Research

Future areas of research may include work with other types of families from different backgrounds and cultures. As these programs took place in science and children's museums, future work could examine the impacts of this program model in other types of institutions or within school systems. Additional research should further examine programs that explicitly address linguistic and navigational capital within family STEM programs.

Conclusions

In spite of decades of targeted programs, there remains a need for more youth to develop lifelong STEM interests and to pursue STEM careers (e.g., Chen, 2013; Musu-Gillette, De Brey, McFarland, Hussar, Sonnenberg, & Wilkinson-Flicker, 2017; Snyder & Dillow, 2012). One factor that these programs fail to take into consideration is the vital role parents play in the education and career aspirations of their children (i.e., Archer & DeWitt, 2016; Crowley et al., 2001; Dabney, Chakraverty, & Tai, 2013; Jones, Taylor, & Forrester, 2011; Lee & Luykx, 2006; Maltese & Tai, 2010; Nugent, Barker, Welch, Grandgenett, Wu, & Nelson, 2015; Perera, 2014). In order to increase the science interests and career aspirations of youth, it is also necessary to build them a support structure in the form of their families (e.g., Archer et al., 2012, Dabney, Tai, & Scott, 2016; Lee & Luykx, 2006; Perera, 2014). Research has shown that a multigenerational intervention may be more beneficial than targeting kids alone (Kaushal, 2014).

Not only is it beneficial for the youth participants, but this study found that a multigenerational intervention is beneficial for the parents as well.

This study sought to build upon the cultural resources parents bring with them in order to help them better support the science interests and career aspirations of their children. While previous programs have examined the level of capital individuals possess, this study utilized a family-based program to increase the cultural capital, including science, social, familial, including aspirational capital, and family science habitus of the participants. The results suggest that this program model was successful for increasing the forms of cultural capital and family science habitus that are foundational for supporting the science interests and career aspirations of youth.

> I can speak to the importance of being inclusive the people who haven't historically who haven't chosen science or math or stem as an option for various reasons whether lack of confidence, or not being targeted or not feeling comfortable but I think this is a great opportunity to kind of bridge that gap and do it in a fun way. It's powerful. It's meaningful. It has really changed us and our lives. It is all about exposure. Exposure is big. So as much as we can expose children, especially those who are not represented in this field to it, I think that's great. The earlier the better (Deja, final interview).

Implications. The findings suggest that organizations seeking to develop similar programs need to engage role models that best reflect the local community, to help build the social capital of the families through communal meals and other group-building activities, and offer engaging hands-on science experiences. When discussing careers, it is important to help the families understand what types of careers are considered STEM and what STEM activities look like.

Based on these findings, it is important that these types of programs specifically address linguistic capital. As the language of science is a barrier to participation in STEM (Claussen & Osborne, 2013), museums and other organizations hosting STEM programs can greatly increase the capital of their families by addressing and utilizing scientific language. Explicitly teaching parents how to probe their children's ideas about the world, teaching them how to support science self-efficacy, and supporting questioning and developing a sense of wonder could go far as supports for developing aspirational and navigational capital. Additionally, to best support the types of capital needed to pursue STEM careers, these programs should also include information to build the navigational capital of families. Understanding how to prepare for STEM careers in school, how to apply for school and scholarships, and other aspects of navigational capital are a barrier for many underrepresented families (Hernandez et al., 2016). Finding ways to support the linguistic and navigational capital of these families is one way museums and other STEM organizations can help support the science career aspirations of youth.

While school-based programs may reach more individuals, there may be tensions between the school and parents (e.g. Morgan, 2010; Murray, Finigan-Carr, Jones, Copeland-Linder, Haynie, & Cheng, 2014; Tezcan-Akmehmet & Luke, 2013) which may lead to fewer underrepresented families participating. The benefit of engaging in these programs in out-of-school settings is that the learning is seen as free choice and tends to come with fewer stressful constraints (Tezcan-Akmehmet & Luke, 2013). However, it is worth investigating how well this type of program works in school settings in order to further support the science interest and career aspirations of youth.

Having access to parents who promote career awareness and encourage career exploration has emerged as an important type of cultural capital (e.g. Ceglie, & Settlage, 2016; Moore, 2005;

Sonnert, 2009; Workman, 2015). By engaging families as a whole, rather than youth as individuals, programs may be able to more effectively support youth science interests and career aspirations. Sustained, engaging, family-based programs out-of-school, and potentially in schools, is one way to approach the need for more youth, particularly women and those from underrepresented groups, to pursue STEM careers.

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Chapter 4: Hidden Science Capital: Parent and Youth Perceptions of Family Science Capital

Abstract

Tools allow for the development of new ideas, behaviors, and creativity and tool use is a culturally situated form of behavior as tools are seen as being social, contextual, and cultural. Science is a field that is integrally bound to tool use. Having access to science tools outside of school is a form of science capital and may influence the science self-efficacy of youth. This study examined the reported tool access in the home of youth (N = 45) and their parents (N = 44). When comparing the access to tools for youth and their parents, four types of tools emerged as significantly different. Significantly fewer youth reported having access to a yardstick, map, thermometer, and ruler than were reported by their parents. The youth participants also reported spending significantly less time engaging in science based activities such as reading a map, using a thermometer, using a ruler, watching science based television, going online to learn about science, going on nature walks, or talking about science with others. Differences were also found between Latinx and African American youth with Latinx youth reporting significantly less access for several tools and experiences. Tools to which youth do not realize they have access to are forms of hidden capital. This study recommends that parents offer their children opportunities to explore these common household tools on their own as well as together. Having prior experiences with science tools before reaching school is an important form of science capital that will set youth up for success in the science classroom.

"Abstract concepts, reasoning, scientific discovery, and other uniquely human endeavors are made possible by language and a panoply of symbolic tools, including numbers, alphabets, maps, models, and various notational systems" (Deloach, Miller, & Rosengren, 1997, p. 129).

Tools act as "mediational means" and allow for the development of new ideas, behaviors, and creativity (Wertsch & Rupert, 1993). Tool use is rooted in culture (Carter, Westbrook, Thompkins, 1999; Vygotsky, 1978) and is inherently social, contextual, and cultural (Carter, Westbrook, Thompkins, 1999). How well tools mediate learning is dependent on how students view and engage with the tools to which they have access (Carter, Westbrook, Thompkins, 1999).

Tools, both symbolic and physical, have emerged as foundational for learning (Vygotsky, 2001) and are an integral part of the discipline of science (Jones et al., 2000; Kirch, 2010). They play a fundamental role in making observations, analyzing data, and sharing results. Students develop ideas about what matters when learning or doing science through their social interactions with others, such as their parents, who teach them different ways of speaking about science, what tools are important, and how they are used (Lemke, 2001).

Tools are also a form of cultural resources associated with doing and learning science, also known as science capital (Archer, Dawson, DeWitt, Seakins, & Wong, 2015). From a sociocultural perspective, tools include both psychological (e.g. language or symbols) and tangible (e.g. a ruler or microscope) resources. This study examines physical tools and science experiences as components of science capital (resources). Here, tools are defined as any cultural object that allows an individual to engage in sense-making in science, technology, engineering, and mathematics (STEM) contexts (Lemke, 2001).

Developing Tool Expertise

Youth gain experiences with tools prior to school through play and tinkering (Jones et al., 2000). Play is seen as a leading factor in development (Vygotsky, 1978, 2001). Play museums have popped up in many countries providing children with opportunities to use hammers, screwdrivers, magnifying glasses, and blocks. Engaging in play involves rules within imaginary situations and actions taken within these settings “teaches the child to guide her behavior not just by the perceived demands of the object [tool] but also by the meaning of the situation” (Vygotsky, 1978, p. 97). Tinkering allows youth to explore and engage with tools and materials in order to develop new ideas and solve questions (Bevan, Gutwill, Petrich, & Wilkinson, 2015). Theorists like Vygotsky (1978, 2001) argue tool use is essential to learning.

Youth construct knowledge when the information they are exposed to is matched to their level of development (Vygotsky, 1978). A student’s “actual developmental level” is related to the tasks that he or she can solve on his or her own whereas the “zone of proximal development” are the tasks a student may be able to accomplish with guidance from an adult or more capable peer (Vygotsky, 1978). Children engaging in play with parents and siblings are often acting within their zone of proximal development (Vygotsky, 1978). Allowing youth access to tools in informal settings through tinkering and playing is one avenue to help youth gain tool expertise and can lay the foundation for learning at more complex levels (Jones et al, 2000).

Recently there has been a movement to engage youth in more tinkering and making, through avenues such as maker spaces found in schools and other settings (Vossoughi & Bevan, 2014). Maker spaces allow students to work collaboratively using tools, design, and inquiry. However, these types of programs are intended to build on the prior experiences youth bring with them to school (Vossoughi & Bevan, 2014) and not all youth bring the same prior experiences to the tasks and challenges that maker spaces employ.

Prior tool expertise may also influence a student's sense of self-efficacy and confidence when engaging in science inquiry. Self-efficacy plays an important role in motivation, affect, and action (Bandura, 1982). Performance accomplishments, one of the four factors influencing self-efficacy, occur as a result of past experiences (Bandura, 1978). Therefore, past experiences with tools may influence a student's levels of science self-efficacy when confronted with laboratory and field investigations. An individual with strong science self-efficacy has a higher belief that he or she will succeed in tasks and activities related to science. This will lead to a student being more likely to select science tasks, such as inquiry activities when given choices, and the student is likely to work harder to successfully complete them (Britner & Pajares, 2006).

Science Capital and Habitus

Many factors influence a student's early access to and engagement with science tools. Parents play a foundational role in helping children learn science, however, they often underestimate their children's ability to learn science and fail to engage their children in science experiences that will set them up for future success in science (NSTA, 2014). Whether or not families engage their children in science is part of their family habitus (Archer, Dewitt, Osborne, Dillion, Willis, & Wong, 2012). Family science habitus includes the dispositions the family holds regarding science. These dispositions influence a family's beliefs about science and how they choose to engage with science (Archer et al., 2012). A family's habitus influences the ability of youth to learn about science in school (Claussen & Osborne, 2103) and can lead to the establishment or absence of a lifelong engagement with science for youth (Jones, Corin, Andre, Childers, & Stevens, 2016).

A family's access to science capital also influences how they engage with science. Science capital in its objectified state includes tools related to science such as books, microscopes, or rulers (Bourdieu, 1986; Claussen & Osborne, 2013). Families with high levels of science capital often have high levels of science literacy and access to cultural and social resources related to science (Archer et al., 2015). Science capital and family science habitus have been found to influence the science career aspirations of youth (Archer et al., 2012). The type and amounts of science capital a family possesses, along with the family's beliefs about whether science careers are possible and probable for their child (habitus), can greatly influence a child's science career aspirations. (Archer et al., 2012). Access to science capital often varies by gender and race (Archer et al., 2015) and this is typically tied to socioeconomic resources. These inequalities can be felt as early as third grade (Kohlhaas, Lin, & Chu, 2010).

Access to Tools by Gender and Race

Gender. There are a number of studies that examine differences in tool access by gender (e.g. Freedman, 2002; Jones et al., 2000; Jones, Howe, & Rua,1999; Jones & Wheatley, 1989, 1990). One study examining gender differences in the science experiences of youth found that boys were more likely to report having out of school experiences with tools than girls (Jones, Howe, & Rua, 1999). Additional studies have found, in the United States and abroad, that boys are more likely to have handled science equipment, performed science experiments, and participated in science-related activities than girls (Freedman 2002; Jones, Howe, & Rua,1999; Jones & Wheatley, 1989, 1990).

These differences in experiences with science are found both in and out of school. Teachers have been described as treating boys and girls differently in the science classroom in terms of the use of science equipment, materials, and manipulatives (Freedman, 2002). A study of teachers in both the United States and Australia found they were more likely to assist groups composed only of girls in the use of tools more frequently than groups of boys (Kahle, Parker, Rennie, Riley, 1993). Teachers may also influence student interaction with tools based on their beliefs about the usefulness of tools, their stereotypical beliefs about their students' abilities and interests, as well as their need to control the activities taking place with the tools (Moyer & Jones, 1998).

Gender stereotypes also influence how boys and girls approach lab-based activities (Jones et al., 2000; Kohlhaas, Lin, & Chu, 2010). Girls are less likely to free play/tinker at school (Carter, Westbrook, Thompkins, 1999; Jones et al., 2000) which may decrease learning (Carter, Westbrook, Thompkins, 1999) and confidence (Freedman, 2002). While boys are more likely to have had experiences manipulating science equipment, girls express a desire to have these experiences (Matyas, 1985). As girls gain experience with science tools, their confidence, interest, and achievement in science grows (Eccles, 1989; Jones, Howe, & Rua, 1999). Allowing girls to have greater access to hands-on labs and science materials has been found to raise girls' achievement in science to the same level of boys' (Freedman, 2002).

Race. Research has found that gaps in science achievement for students of color begin prior to entering school (Chapin, 2006). Often, this is a result of poverty levels which influences the quality of resources to which a child has access to at home (Kohlhaas, Lin, & Chu, 2010). Students of color may also be disadvantaged by the opportunities and resources they have access to in their schools (Kohlhaas, Lin, & Chu, 2010).

Youth access to tools at home may lead to a better understanding of science tools in the classroom. Without opportunities to engage with tools, students may enter learning contexts that require tool use without the needed prior experience (Cater, Westbrook, & Thompkins, 1999).

“Science inquiry, unlike many other fields of study, is integrally bound to the use of materials and equipment” (Jones et al., 2000, p. 760). Students need early experiences with tools to be successful in later school settings where tools are necessary for science learning (Carter, Westbrook, & Tompkins, 1999).

Tools in the Science Classroom

Tools play an important role in the *Next Generation Science Standards* (NGSS Lead States, 2013). They are particularly important for the cross cutting concept: “Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance” (NGSS Lead States, 2013, pp. 413). Having access to rulers, meter sticks, and scales provides students with the mediational means (Vygotsky, 2001) to develop these critical scale and quantity concepts.

In addition to learning scale and quantity concepts, tool use may influence an individual’s ability to develop science process skills which are necessary for science inquiry. Basic science process skills include “Measuring- using both standard and nonstandard measures or estimates to describe the dimensions of an object or event. Example: Using a meter stick to measure the length of a table in centimeters” (Padilla, 1990, p. 1). Understanding the basic science process skill of measuring is fundamental for developing integrated science process skills such as experimenting and formulating models (Padilla, 1990). To learn these more complex skills, which are necessary for science inquiry, the skills must be taught and practiced over time (Padilla, 1990). Students need opportunities to experiment with these tools in a variety of settings in order to gain mastery of these skills, such as tool use (Padilla, 1990). Using tools for science inquiry allows a student to learn how tools work and what they can accomplish which allows them to select appropriate tools for a task (Carter, Westbrook, & Tompkins, 1999). “We cannot expect students to excel at skills they have not experienced or been allowed to practice” (Padilla, 1990, p. 3).

Science capital and family science habitus influences access and engagement with science (Archer et al., 2012). Families with high levels of science capital and habitus have been shown to provide “specific opportunities, resources, and support for children to develop a practical ‘feel’ and sense of mastery of science” (Archer et al., 2012, p. 11). These opportunities to explore tools and science experiences are a valuable form of capital youth can draw upon when entering school.

Research Questions

As described above, science tool access and early experiences are an important part of science capital and habitus and it follows that documenting the access youth report having to science tools at home can inform educational planning. Understanding the science capital (including physical resources as well as science experiences) can provide insight into how and why some students succeed in science and others may not. Furthermore, by examining science capital of both parents and youth, we can gain information about how science capital changes from one generation to the next. The research questions that guided this this study included:

1. What access do youth report having to science tools at home?
2. What access do parents report having to science tools at home?
3. What science-related experiences do youth report having outside of school?
4. What science-related experiences do parents report having?

Methods

This study is part of a larger study of the effects of family-based STEM programming on the science interests and career aspirations of youth. As part of the study, the participating youth and at least one parent or guardian completed the *NextGen Scientist Survey* (described below) at the beginning of the intervention. The participants in this study were part of a ten-month, family STEM program aimed at increasing the science capital and family habitus of families from groups underrepresented in science and from low wealth communities. The programs took place at three museums located in the southeastern part of the United States. The museums included a natural sciences museum, a children's museum, and a science center and planetarium. The natural sciences museum and the children's museum were located downtown within an urban area. The natural sciences museum was run by the state and free to the public. The children's museum was a nonprofit museum focused on play. The science center and planetarium was part of a university and located on the university campus.

Survey

The *NextGen Scientist Survey* (Jones, Ennes, Weedfall, Chesnutt, & Cayton, 2019 under review) was developed to examine the science capital and family science habitus of youth and their parents. This survey has been found to be valid and reliable and measures four factors (science expectancy value, science experiences, future science task value, and family science achievement values) that contribute to science career aspirations. See Jones, Ennes, Weedfall, Chesnutt, and Cayton (under review) for more details about the survey.

In this study, each youth and their adult parent or guardian took the *NextGen Scientist Survey*. The surveys, offered in both English and Spanish, were administered with paper and pencil and were later digitally transcribed. On the survey, respondents were asked whether they had access to 20 common tools related to mathematics or science at home. These questions were coded 1 for "yes" and 0 for "no." They were also asked how often they participated in 13 different science-related activities over the past year. The participants were able to select from four options: "never", "1 time", "2-4 times", or "5 or more times." These questions were coded from zero to three with never scoring as a zero and "5 times or more" scoring a three. The youth survey can be found in Appendix A and the adult survey can be found in Appendix B.

Participants

Participants for this study were recruited by each of the museums through their partnerships with Title I schools and after school programs within the local community. The targeted participants were to be selected from groups underrepresented in STEM and from low wealth communities[1].

The participating youth (N = 45) were in grades 3-5. Most of the youth were between the ages of eight to eleven and just over half identified as female. Approximately two-thirds of the youth identified as African American, a quarter Latinx, and the rest indicated White or other races (Table 1).

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[1] While the targeted population was families from low wealth communities, information about socioeconomic status was not gathered on the survey.

Table 1: Youth demographics

	Frequency	Percent
Gender (n = 44)		
Female	23	52.3
Male	21	47.7
Age (n = 40)		
8	12	30.0
9	16	40.0
10	7	17.5
11	5	12.5
Race (n = 44)		
African American	28	63.6
Latinx	11	25.0
White	3	6.8
Other	2	4.5

While there were 45 youth participants, one parent had two youth in the program for a total of 44 adult participants. These adult participants were primarily female and more than half identified as African American. The parents indicated they mostly spoke English at home with a few speaking Spanish or other languages, such as Hungarian, at home (Table 2). Most of the parents reported that they lived in urban or suburban areas with a few families coming from rural areas. When asked about their education on the pre-assessment, approximately half (47.7%) reported they had completed four or more years of college. (Table 2)

Table 2: Parent/guardian demographics

	Frequency	Percent
Gender		
Female	41	93.2
Male	3	6.8
Race		
African American	24	54.5
Latinx	7	15.9
White	9	20.5
Other	4	9.1
Language		
English	36	83.7
Spanish	5	11.6
Other	2	4.7
Home Location		
Urban	18	40.9
Suburban	18	40.9
Rural	8	18.2
Education		
Some high school	3	6.8
Graduated high school	4	9.1
Some college	10	22.7
Two years college	6	13.6
Four or more years of college	21	47.7

Analyses

For the youth and adult participants, a tool score was found by coding "yes" as one and "no" as zero. These numbers were added together to create a tool score ranging from zero to 20. The frequencies of tool access reported by each participant were then determined. An independent samples t-test was conducted to determine if there were significant differences between the tools to which parents reported having access versus the youth responses. For each of the items related to science experiences, the mean amount of time participants reported spending on each activity was calculated. Another independent t-test was calculated to identify significant differences between the amount of time the adults and youth participants reported spending on various science-related activities.

Results

In the section that follows, the results related to tool access and time spent on science experiences are described. The results were examined for the elementary youth, their parents, and the differences between the two groups of participants.

Youth Tool Access

Each participant was asked to identify whether they had 20 different tools available at home. Out of the 20 tools, the youth reported a mean tool score of 11.16 (SD = 1.13). Almost all of the youth (95.6%) reported having a camera at home. Approximately a third or more indicated they did not have access to Legos® (31.1%), building blocks (31.1%), a thermometer (35.6%), a weight scale (37.8%), or a magnifying glass (42.2%). More than half indicated they did not have access to a map (51.1%), compass (60.0%), yardstick (60.0%), kitchen scale (62.2%), science kit (66.7%), health monitor (68.9%), telescope (72.7%), Lincoln Logs® (77.8%), or microscope (86.7%). Youth results for the 20 tools can be seen in Table 3.

Table 3: Reported differences in home tool access for elementary youth and parent participants.

	Youth			Parents						
Tool	n	Yes[a]	No[b]	n	Yes[a]	No[b]	Mean Difference (SE)	t	df	*p*
Yardstick or Meter stick	45	40.0	60.0	44	72.7	27.3	-0.33 (0.10)	-3.26	87	.002*
Map	45	48.9	51.1	43	74.4	25.6	-0.26 (0.10)	-2.52	86	.014*
Thermometer	45	64.4	35.6	44	86.4	13.6	-0.22 (0.09)	-2.45	87	.016*
Ruler	45	84.4	15.6	44	97.7	2.3	-0.13 (0.06)	-2.23	87	.029**
Compass	45	40.0	60.0	44	59.1	40.9	-0.19 (0.11)	-1.81	87	.073
Health Monitor	45	31.1	68.9	43	46.5	53.5	-0.15 (0.10)	-1.49	86	.141
Calculator	45	86.7	13.3	44	95.5	4.5	-0.09 (0.06)	-1.45	87	.151
Legos®	45	68.9	31.1	44	81.8	18.2	-0.13 (0.09)	-1.41	87	.161
Building Blocks	45	68.9	31.1	44	59.1	40.9	0.10 (0.10)	0.96	87	.341
Timer	45	84.4	15.6	44	90.9	9.1	-0.07 (0.07)	-0.92	87	.360
Measuring Cups	45	88.9	11.1	44	93.2	6.8	-0.04 (0.06)	-0.70	87	.485
Magnifying Glass	45	57.8	42.2	44	63.6	36.4	-0.06 (0.11)	-0.56	87	.577
Lincoln Logs®	45	22.2	77.8	44	27.3	72.7	-0.05 (0.09)	-0.55	87	.586
Kitchen Scale	45	37.8	62.2	44	43.2	56.8	-0.05 (0.11)	-0.51	87	.608
Telescope	44	27.3	72.7	44	22.7	77.3	0.05 (0.09)	0.49	86	.627
Camera	45	95.6	4.4	44	93.2	6.8	0.02 (0.05)	0.48	87	.631
Weight Scale	45	62.2	37.8	44	65.9	34.1	-0.04 (0.10)	-0.36	87	.721
Microscope	45	13.3	86.7	44	15.9	84.1	-0.03 (0.08)	-0.34	87	.734
GPS	44	84.1	15.9	44	86.4	13.6	-0.02 (0.08)	-0.30	86	.767
Chemistry or Science Kit	45	33.3	66.7	44	34.1	65.9	-0.01 (0.10)	-0.08	87	.941

Note: [a] Yes was coded "1" [b] No was coded "0" in order to find the mean difference. * $p < .01$, ** $p < .05$.

When examining differences in reported tool access by gender, there was not a significant difference between the tool scores of males (M = 11.11, SD = 4.32) and females (M = 9.86, SD = 3.52). However, two individual items were significantly different. Significantly more boys than girls reported having a chemistry or science kit (t(42) = 2.571, *p* = .014) and a health monitor (t(42) = 2.221, *p* = .032) (Table 4).

Table 4: Mean frequency of reported access to tools at home by gender.

	Male			Female						
	n	Yes[a]	No[b]	n	Yes[a]	No[b]	Mean Difference	t	df	*p*
Chemistry or Science Kit	21	52.4	47.6	23	17.4	82.6	.350	2.571	42.00	.014*
Health Monitor	21	47.6	52.4	23	17.4	82.6	.302	2.221	42.00	.032*
Microscope	21	23.8	76.2	23	4.3	95.7	.195	1.914	42.00	.062
Building Blocks	21	81.0	19.0	23	56.5	43.5	.244	1.759	42.00	.086
Telescope	20	40.0	60.0	23	17.4	82.6	.226	1.663	41.00	.104
Calculator	21	81.0	19.0	23	91.3	8.7	-.104	-0.973	35.95	.337
Map	21	42.9	57.1	23	52.2	47.8	-.093	-0.607	41.69	.547
Measuring Cups	21	85.7	14.3	23	91.3	8.7	-.056	-0.567	38.40	.574
Yard/Meter Stick	21	42.9	57.1	23	34.8	65.2	.081	0.538	41.27	.594
Compass	21	42.9	57.1	23	34.8	65.2	.081	0.538	41.27	.594
Measuring Tape	20	80.0	20.0	23	73.9	26.1	.061	0.464	40.88	.645
Thermometer	21	66.7	33.3	23	60.9	39.1	.058	0.391	41.85	.697
Ruler	21	85.7	14.3	23	82.6	17.4	.031	0.276	41.99	.784
Timer	21	85.7	14.3	23	82.6	17.4	.031	0.276	41.99	.784
Kitchen Scale	21	38.1	61.9	23	34.8	65.2	.033	0.223	41.45	.825
Legos	21	66.7	33.3	23	69.6	30.4	-.029	-0.201	41.41	.841
Lincoln Logs	21	23.8	76.2	23	21.7	78.3	.021	0.16	41.33	.874
Weight Scale	21	61.9	38.1	23	68.1	31.9	.010	0.069	41.66	.945
Camera	21	95.2	4.8	23	95.7	4.3	-.004	-0.064	41.21	.949
GPS	21	85.7	14.3	22	86.4	13.6	-.006	-0.06	40.81	.952
Magnifying Glass	21	57.1	42.9	23	56.5	43.5	.006	0.041	41.64	.968

Note: [a] Items were coded 1 for "yes." [b] Items were coded 0 for "no." * $p < .05$.

Differences were also examined for youth that identified as African American and Latinx[2]. African American youth had a statistically higher mean tool score of 11.23 (SD = 4.06) than the Latinx youth's tool score of 8.00 (SD = 2.61), (t(28.90) = 2.89, *p* = .007). African

[2] Note: Participants were recruited from African American and Latinx communities. There were only three youth who identified as being White and two who identified as another race and these participants were not included in the racial analyses.

American participants reported having significantly more access than Latinx participants for six items: a chemistry kit (t(37) = 3.007, *p* = .005), a ruler (t(37) = 2.381, *p* = .023), a thermometer (t(37) = 2.365, *p* = .023), Legos® (t(37) = 2.365, *p* = 023), a calculator (t(37) = 2.381, *p* = .023), and a map (t(37) = 2.285, *p* = .028). Table 5.

Table 5: Difference in reported access to tools between African American and Latinx youth.

	African American			Latinx						
	n	Yes	No	n	Yes	No	Mean Difference	t	df	*p*
Chemistry or Science Kit	28	46.4	53.6	11	0	100	0.46	3.007	37.00	.005*
Ruler	28	92.9	7.1	11	63.6	36.4	0.29	2.381	37.00	.023**
Calculator	28	92.9	7.1	11	63.6	36.4	0.29	2.381	37.00	.023**
Map	28	57.1	42.9	11	18.2	81.8	0.39	2.285	37.00	.028**
Thermometer	28	75.0	25.0	11	36.4	63.6	0.39	2.228	16.36	.040**
Legos	28	75.0	25.0	11	36.4	63.6	0.39	2.228	16.36	.040**
Magnifying Glass	28	60.7	39.3	11	27.3	72.7	0.33	1.975	19.46	.063
GPS	27	92.6	7.4	11	72.7	27.3	0.20	1.659	36.00	.106
Microscope	28	17.9	82.1	11	0	100	0.18	1.506	37.00	.141
Measuring Tape	27	85.2	14.8	11	63.6	36.4	0.22	1.481	36.00	.147
Yard/Meter Stick	28	42.9	57.1	11	18.2	81.8	0.25	1.447	37.00	.156
Health Monitor	28	35.7	64.3	11	18.2	81.8	0.18	1.055	37.00	.298
Lincoln Logs	28	21.4	78.6	11	9.1	90.9	0.12	1.025	25.42	.315
Building Blocks	28	71.4	28.6	11	54.5	45.5	0.17	0.939	16.46	.361
Measuring Cups	28	92.9	7.1	11	81.8	18.2	0.11	0.838	13.44	.416
Telescope	28	28.6	71.4	11	18.2	81.8	0.10	0.694	20.76	.496
Camera	28	96.4	3.6	11	90.9	9.1	0.06	0.565	13.21	.581
Compass	28	35.7	64.3	11	45.5	54.5	-0.10	-0.534	17.28	.600
Kitchen Scale	28	35.7	64.3	11	27.3	72.7	0.08	0.501	19.11	.622
Weight Scale	28	60.7	39.3	11	54.5	45.5	0.06	0.336	17.57	.741
Timer	28	82.1	17.9	11	81.8	18.2	0.00	0.023	17.76	.982

Note: [a] Items were coded 0 for “no” and 1 for “yes.” * $p < .01$. ** $p < .05$.

Parent Tool Access

When asked, nearly all of the parents reported having a ruler (97.7%) or calculator (95.5) at home. About a quarter of the parents said they did not have a map (25.6%) or a yardstick (27.3%). Approximately a third or more reported they did not have access to a weight scale (34.1%), magnifying glass (36.4%), compass (40.9%), or building blocks (40.9%). More than half of the parents indicated they did not have access to a health monitor (53.5%), kitchen scale (56.8%), chemistry or science kit (65.9%), Lincoln Logs® (72.7%), a telescope (77.3%), or a microscope (84.1%) (Table 3).

Elementary Youth vs Parent Tool access

The results for the parent and youth participants were compared to identify differences in reported tool access (Table 3). Significantly fewer youth than parents reported having access to a yardstick ($t(87) = -3.26$, $p = .002$), a map ($t(86) = -2.52$, $p = .014$), a thermometer ($t(87) = -2.45$, $p = .016$), and a ruler ($t(87) = -2.23$, $p = .029$) (Table 3).

Youth respondents were asked how many times they had engaged in science-related activities, including tool use, outside of school in the last year (Table 6).

Table 6: Mean difference between the amount of time elementary youth and parents report spending on science-related activities outside of school.

How many times in the last year have you: [a]	Youth		Parents		Mean Difference (SE)	t	df	*p*
	n	M (SD)	n	M (SD)				
Read a map	45	0.82 (1.07)	43	1.79 (1.17)	-0.97 (0.24)	-4.06	86	< .001*
Used a thermometer	45	1.02 (1.10)	43	2.21 (0.89)	-1.19 0(.22)	-5.56	86	< .001*
Watched science tv shows	45	1.47 (1.22)	44	2.32 (0.96)	-0.85 (0.23)	-3.66	87	< .001*
Used a ruler	43	1.72 (1.14)	44	2.39 (0.87)	-0.67 (0.22)	-3.07	85	.003**
Gone online to learn about science	45	1.40 (1.18)	44	1.98 (1.02)	-0.58 (0.23)	-2.47	87	.015***
Gone on a nature walk	45	1.62 (1.13)	44	2.14 (0.85)	-0.51 (0.21)	-2.42	87	.018***
Talked about science with others	45	1.62 (1.19)	43	2.16 (0.87)	-0.54 (0.22)	-2.42	86	.018***
Used binoculars or a telescope	45	1.31 (1.16)	44	0.89 (1.04)	0.43 (0.23)	1.81	87	.073
Read a book about science	44	1.39 (1.15)	44	1.77 (0.99)	-0.39 (0.23)	-1.70	86	.093
Planted a garden	45	1.29 (1.06)	43	1.07 (0.96)	0.22 (0.22)	1.02	86	.313
Gone to a zoo, aquarium, museum, or planetarium	45	1.71 (1.12)	44	1.89 (0.87)	-0.18 (0.21)	-0.82	87	.413
Built or taken things apart	45	0.69 (1.00)	44	0.82 (1.00)	-0.13 (0.21)	-0.61	87	.542
Gone hunting or fishing	45	0.93 (1.12)	44	0.89 (1.04)	0.05 (0.23)	0.21	87	.838

Note: [a]Each item was scored "never" (0), "1 time" (1), "2-4 times" (2), or "5 or more times" (3).
* $p < .001$, ** $p < .01$, *** $p < .05$.

There were no significant differences in the amount of time boys reported spending on the activities versus girls. However, African American youth reported spending significantly more time on three activities than Latinx youth (Table 7). These activities included talking about science-related topics with other people (t(37) = 2.245, *p* = .002), going hunting or fishing (t(37) = 3.121, *p* = .003, and doing science activities like scouts, 4-H, or science camps (Table 7).

Table 7: Difference in amount of time spent engaging in science-related activities outside of school between elementary African American and Latinx youth.

	African American	Latinx			
In the last year, how many times have you engaged in these activities outside of school?[a]	M(SD)	M(SD)	t	df	p
Talked about science related topics with other people	1.93 (1.05)	0.73 (0.65)	3.25	37	.002*
Gone hunting or fishing	1.00 (1.05)	0.00 (0.00)	3.12	37	.003*
Done science activities like scouts, 4-H, or science camps	1.33 (1.30)	0.18 (0.60)	2.80	36	.008*
Watched science tv programs	1.64 (1.25)	0.82 (0.98)	1.95	37	.058
Built or taken things apart like a radio, watch, or computer	0.86 (1.04)	0.27 (0.65)	1.72	37	.093
Read a book or magazine about science	1.36 (1.13)	0.70 (0.82)	1.68	36	.101
Done experiments or used science kits	1.46 (1.29)	0.73 (1.10)	1.67	37	.104
Read a map to find your way	1.00 (1.19)	0.36 (0.67)	1.67	37	.104
Collected shells or rocks	2.04 (1.17)	1.45 (1.04)	1.44	37	.159
Gone online to learn about science on science websites or videos	1.54 (1.14)	1.00 (1.18)	1.31	37	.199
Used a ruler, measuring tape, or measuring stick	1.77 (1.11)	1.27 (1.10)	1.25	35	.220
Used a thermometer to measure temperature	1.00 (1.05)	0.73 (1.01)	0.74	37	.467
Used binoculars or a telescope	1.29 (1.15)	1.00 (1.27)	0.68	37	.501
Gone to a museum, zoo, aquarium, or planetarium	1.79 (1.20)	1.55 (0.93)	0.60	37	.555
Gone on a nature walk	1.61 (1.13)	1.45 (1.23)	0.38	37	.707
Planted seeds and watched them grow	1.32 (1.09)	1.27 (1.01)	0.13	37	.899

Note: [a]Each item was scored “never” (0), “1 time” (1), “2-4 times” (2), or “5 or more times” (3). * $p < .01$.

The parents were also asked how often they spent engaging in the same science-related activities in the last year (Table 6). When comparing youth and their parents, youth reported significantly less fewer experiences than their parents for several activities, three of which involve tool use. The activities for which youth reported spending less time than their parents included reading a map (t(86) = -4.06, $p < .001$), using a thermometer (t(86) = -5.56, $p < .001$), watching tv shows related to science (t(87) = -3.66, $p < .001$), using a ruler (t(85) = -3.07, *p* =

.003), going online to learn about science topics (t(87) = -2.47, *p* = .015), going on a nature walk (t(87) = -2.42, *p* = .018), or talking about science with others (t(86) = -2.42, *p* = .018). Table 6.

Limitations

This study has a limited sample size and results should not be generalized beyond this sample. Additionally, the participants in this study were volunteers and their science interests may not be representative of the larger populations. The area where the program took place offers many science opportunities to engage with science outside of the program which may have influenced the results. Many of the youth participants were concurrently enrolled in a local afterschool program which may have offered more opportunities to engage in science outside of school than may be offered to youth not enrolled in afterschool programs. The parents in this study had a wide range of educational levels and may not be representative of parents from low wealth communities even though they were recruited from organizations that serve low socioeconomic families. Care should be taken when generalizing these results to other populations.

Discussion

Youth Responses

The youth in this study report having access to a variety of science-related tools such as a camera, measuring cups, and a calculator. However, many students in this study reported a lack of access to tools such as a thermometer, scale, magnifying glass, science kits, microscopes, or telescopes. While not every child will grow up with a microscope, the students growing up without perceived access to foundational science tools such as measuring cups (11.1%), a calculator (13.3%), ruler (15.6%), building blocks (31.1%), thermometer (31.1%), scales- either bathroom (37.8%) or kitchen (62.2%), magnifying glass (42.2%), or yardstick (60.0%) will be at a disadvantage when they enter the science classroom (Claussen & Osborne, 2013). Without the ability to develop basic science process skills using these tools, they may lag behind their classmates in developing the integrated process skills needed to conduct science inquiry in the classroom (Padilla, 1990).

Imagine a student without access to a scale of any form, who has never had an opportunity to weigh herself or other objects. When she reaches fifth grade, she is expected to master the NGSS physical science standard: “Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved” (NGSS Lead States, 2013). Now, she is not only learning that matter is conserved but to do so, she must first learn to use a scale.

In addition to science process skills such as measuring, early experiences with science tools are important for building the science self-efficacy of students. Students such as the one described above lack the performance accomplishments needed to support high levels of self-efficacy (Bandura, 1978). If she is unsuccessful in her attempt to master the scale and discover that matter retains mass, then she is less likely to expend as much effort in her next attempt. She may know what needs to be done to complete the task (weigh the object) but she may doubt her ability to complete the task. This belief will influence whether she will even attempt the next task, how hard she will work, and how long she will even try to accomplish the task (Bandura, 1978). Supporting youth science self-efficacy is particularly important for girls. While there appears to be no difference in science self-efficacy between boys and girls in kindergarten, a gender gap has been found as early as middle school where boys develop higher levels of self-efficacy than girls (Patrick, Mantzicopoulos, & Samarapungavan, 2009).

When the results were examined for gender differences within this study, significantly more boys reported having access to chemistry or science kits and health monitors. Previous studies have shown that boys frequently report engaging with tools more frequently than girls (e.g. Freedman 2002; Jones et al., 2000; Jones, Howe, & Rua,1999; Jones & Wheatley, 1989, 1990) however, for the current study, boys and girls only varied on access to two tools. When examining how often they report engaging in science-related activities that include tool use, there were no significant differences between boys and girls.

The youth in this study were predominantly African American or Latinx. When differences for these two groups were examined, several significant differences emerged. African American youth reported having significantly more access to six foundational science tools: a science kit, a ruler, a thermometer, Legos®, a calculator, a map, and a magnifying glass. All of the Latinx youth participants said they did not have access to a science kit or a microscope. African American youth also reported engaging in three science-related activities more often than the Latinx youth, talking about science with others, hunting or fishing, and doing science-related activities such as scouts or 4-H. Although all youth were recruited from programs that serve youth with low or limited income, we cannot eliminate the possibility that there could be socioeconomic differences in the Latinx and African American populations. More research is needed to examines the intersection of culture and access to tools in home environments to identify ways to specifically support the science capital and family habitus of Latinx families.

Perceptions of Youth and Parents

When comparing the reported tool access of youth to that of their parents, there were significant differences for four items: a yardstick, map, thermometer, and ruler. One can speculated that adults might use maps more often in traveling but one would expect youth to use objects such as thermometers, yardsticks, or rulers at home. Tools such as these play a central role in scientific inquiry in school as discussed above and are a form of hidden capital. Hidden capital typically refers to cultural resources underrepresented groups bring with them that are unrecognized by the educational system (Drazan, Scott, Hoke, & Ledet, 2014). In this situation we define hidden capital as the resources to which youth unaware they have access. The items listed in this study are useful scientific tools and many are fairly common in the home such as rulers and thermometers. In order to help their children engage with these foundational tools, parents must consciously give their children opportunities to engage in free exploration with them. As discussed above, tinkering with these tools helps youth to build experience to draw from when they enter school but also helps them develop ideas about how the tools work and why (Bevan, Gutwill, Petrich, & Wilkinson, 2015; Carter, Westbrook, Thompkins, 1999). It is worth noting that there were no families that reported lacking access to all of these tools.

Parents are responsible for early access to science resources and experiences (Dabney, Chakraverty, & Tai, 2013) and therefore it would be beneficial for them to either engage their child in using these tools with them or offer their children the ability to explore these tools on their own. The results suggest that parents must explicitly let their children know they have access to these types of tools. Youth who grow up without access to these culturally identified tools of science are at a disadvantage when they enter school as these are part of the dominant cultural capital of science (Claussen & Osborne, 2013). If youth do not have prior experiences with these types of tools, they run the risk of being disadvantaged by having to learn how to use the tool or lacking knowledge of what tools are appropriate while simultaneously learning new concepts in science (Carter, Westbrook, & Thompkins, 1999).

It is also worth considering the role of technological tools in and out of school. For example, there are now smart phone applications that allow you to use your phone as a ruler to measure an object or as a GPS to find your way. A single smart phone can now be used as a camera, calculator, ruler, GPS, compass, health monitor, and even a telescope or microscope (e.g. Horejsi, 2017; Vieyra, Vieyra, Jeanjacquot, Marti, & Monteiro, 2015). Many families invest in a smart phone including 67% of individuals who make less than $30,000 a year, 82% of individuals who make between $30,000-$49,999 a year, and 69% of individuals with low levels of education (PEW Research Center, 2018). This means that many families from low income communities have access to a smart phone which may offset the lack of tool access.

What is not known is to what extent these electronic tools can play the same role as physical tools. If these virtual tools emerge as effective in mediating learning for size and scale concepts, then some discrepancies for economically disadvantaged youth may be offset. However, virtual tools may not completely replace physical tools in developing conceptual understanding (Zacharia, Loizou, & Papaevripidou, 2012). A study of kindergarteners examined the effects of physical versus virtual tools for categorizing objects by mass using a balance beam. For students with alternative conceptions of what the purpose of a balance beam was, it was necessary to first let youth touch the weights and physically interact with the balance beam before they could complete the task. The youth without prior experience needed to hold the weights and move them on the beam before they could develop a more fundamental understanding of what the tool did (Zacharia, Loizou, & Papaevripidou, 2012). However, those with prior experiences with the tool were able to use the virtual representation without difficulty.

In addition to reporting greater access to tools in the home, the parents in this study also reported spending more time than their children engaging in seven science-related activities.

These include talking to others about science, going on nature walks, going online to learn about science, watching science-based television shows, reading a map, using a thermometer, and using a ruler. Engaging in these activities with their parents would support youth in developing understandings about science.

In a report on how parents talk to their children about science, parents indicated they wanted to engage their children but were unsure how to go about doing so (Silander et al., 2018). Of the parents in their study, 71% reported they would do more science at home if they knew what to do with everyday materials. They also reported they would do more science with their children if they knew what their children needed to know about science and this was particularly true for parents from low wealth and low educational levels (Silander et al., 2018) Allowing their children to engage in activities using household tools or watching science based television programming with their child are just two simple ways parents can engage their children in science that does not require the parents to have strong content knowledge (Lee & Luykx, 2006).

Implications

Parents play an important role preparing their children to succeed in science. Learning to engage in science practices, such as tool use, is a form of cultural capital that youth develop over time by engaging with their parents and out-of-school science experiences such as tinkering (Claussen & Osborne, 2013). Groups that are underrepresented in science often lack the cultural capital that dominant groups are afforded (Claussen & Osborne, 2013). However, there are ways parents can help support their children in science even if they do not feel like they have the expertise (Lee & Luykx, 2006). To help youth gain more experience with science tools, parents can engage their kids in the activities they are already doing such as talking about science at home, looking up information about science online, and watching science-related television together (Silander et al., 2018). Parents can also offer their children opportunities to play and tinker with science tools which allows them to develop their own understanding of the tools (Bevan, Gutwill, Petrich, & Wilkinson, 2015; Carter, Westbrook, Thompkins, 1999; Vygotsky, 1978). Parents can increase access and experiences for their child with every day tools such as measuring cups and spoons, screw drivers, hammers, rulers, and other common household tools. As many families already have these resources, parents need only make a conscious effort to engage their children in tool use. This has the potential to strengthen their children's levels of self-efficacy and confidence in conducting science inquiry (Britner & Pajares, 2006) and will better prepare them for a successful experience in the science classroom (Carter, Westbrook, Thompkins, 1999).

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Chapter 5: Conclusion

As our society becomes more science and technology oriented, it will be vital to foster STEM interests and career aspirations as well as to develop scientifically literate citizens. The studies in this dissertation examined the effects of a museum-based, family STEM program aimed at increasing the science capital and family science habitus of youth from nondominant families from low wealth communities. These studies extend the work of Archer and her colleagues (2012, 2015) from the theoretical to the practical. Archer conducted studies to use science capital and family science capital as a lens to explain the differences in science interests and career aspirations of youth in England (Archer et al., 2014) and to develop a tool for examining the science capital and family habitus youth in England (Archer et al., 2012, 2015). This study sought to build on their work by identifying whether it is possible to enhance the science capital and family science habitus of youth and their families from underrepresented groups and low wealth communities.

The study outlined in this dissertation targeted families as a whole rather than youth as individuals to increase science capital and family science habitus in order to build and support the STEM career aspirations of youth. Parents play an important role in their children's education regardless of race or socioeconomic status (Wilson & Gross, 2018). However, few studies have examined how family and parents can influence the career aspirations of elementary aged children (Whiston & Keller, 2004). Parents influence their children through direct ways such as through their attitudes, encouragement, expectations, interests, aspirations, and role modeling which is important regardless of race or socioeconomic status (Fisher & Padmawidjaja, 1999). They also effect their children's career aspirations through indirect pathways such as influencing their children's levels of self-efficacy which influence career aspirations (Sawitri, Creed, & Zimmer-Gembeck, 2014). Access to parental support allows children to explore careers, increasing their motivation and confidence which may then lead to an increase in self-efficacy and help them react positively to challenges to their career aspirations (Guan, Capezio, Restubog, Read, Lajom, & Li, 2016). Regardless of race, parents often hold high career aspirations for their children (Fisher & Padmawidjaja, 1999). The results of this study support engaging parents in family STEM programs so they can leverage their high aspirations and help build and support their children's STEM career interests.

The study utilized expectancy value theory (Wigfield & Eccles, 2000) to examine how the program influenced multiple factors that support career aspirations. The findings shared in this dissertation suggest that it is possible to support and increase several factors associated with science capital and family science habitus including the science expectancies and experiences of youth. In addition to influencing the youth participants, the program positively influenced the cultural capital (science, social, navigational, aspirational, linguistic, familial) and family science habitus of the parent/guardian participants. Equipping parents with tools to promote career awareness and encourage career exploration has emerged as an important type of cultural capital for youth (e.g. Ceglie & Settlage, 2016; Moore, 2005; Sonnert, 2009; Workman, 2015).

Building upon the cultural capital parents bring with them allows parents to leverage the resources they have to better support their children. The forms of cultural capital examined in this study often engaged in positive feedback loops where one form of capital would help parents leverage other forms. For example, increasing the social capital of the parents in this program allowed them to learn about new resources from other parents which increased their navigational capital. The increase in navigational capital then increased the aspirational capital of many of the parents. By increasing the cultural capital and family habitus of the parents, we developed a better support system for the youth within the program. Many parents felt better able to support their children's aspirations which is vital for long term persistence.

Not only did parents feel able to support their children's aspirations, the increase in cultural wealth also increased their own aspirations for themselves. Much of the research on increasing diversity in STEM fields focuses on individuals in K-16 and little research focuses on bringing adult learners into STEM fields. Rather than waiting for youth in STEM programs to grow old enough to participate in the STEM workforce, it may be worth examining how to bring underrepresented adults into the STEM fields. Filling the need for STEM professionals will take a multiprong approach and this may be a unique avenue that has yet to be examined.

In addition to examining the effects of the program on the participants, this dissertation also examined the perceived access to science tools which youth reported having. Tools play an integral part of science (Jones et al., 2000) and early experiences with these tools may greatly impact the science self-efficacy of youth when they enter school (Carter, Westbrook, & Thompkins, 1999). Given the amount of hidden capital found in this study, it is vital that parents help their children have a better understanding of the resources and tools to which they have access. Engaging their children in tool use or allowing time for free play and tinkering is one technique parents can use to help their children be better prepared for science in school.

While there are a variety of factors that influence science interests and career aspirations, this study found families to be particularly important. By engaging families as a whole, rather than youth as individuals, programs may be able to more effectively support youth science interests and career aspirations. Sustained, engaging, family-based programs out-of-school, and potentially in schools, is one way to approach the need for more youth, particularly women and those from underrepresented groups, to pursue STEM careers and life-long science interests.

Museums and schools should further examine the efficacy of this model in other settings and with other populations. The need to fill future STEM positions and to have a scientifically literate population is a complex problem and will require multiple solutions. This study supports the use of sustained, museum-based, family STEM programs for the development of science capital and family habitus that play an important role in the development of STEM interests and career aspirations in underrepresented youth and their families.

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APPENDICES

Appendix A

Youth *NextGen Scientist Survey*

Youth Survey

Directions: Please answer each question in this survey. There are no right or wrong answers. We are interested in your ideas.

---

1. What is your name? (First and Last)

---

2. Select your museum program

Marbles Kids Museum

Morehead Planetarium

NC Museum of Natural Sciences

---

3. When were you born? (Month, Day, Year)

---

4. What is your grade level?

Grade 3

Grade 4

Grade 5

Grade 6

---

5. I am:

African American/African

Caucasian/European

Hispanic/Latino

American Indian/Native Alaskan

Native Hawaiian/Other Pacific Islander

Middle Eastern

South Asian/Indian

East Asian

Other ____

---

6. I am:

Male

Female

---

7. What language do you speak at home?

English

Spanish

Other ____

---

8. **Tell us about yourself.** There are no right or wrong answers!

	Strongly Disagree	Disagree	In-Between	Agree	Strongly Agree
I plan to go to college.					
When I am older, I will need science for my job.					
I like to think about how things like computers or phones work.					
I would like to have a job that uses science.					
It is important to study science even if you don't want a science job.					
I like to think about how bridges hold up heavy things like cars.					
After I finish high school, I will use science often.					

9. What do you want to be when you grow up?

10. Where did you hear about this job? (Check all that apply)

- ☐ Teacher
- ☐ Family Member
- ☐ Family Friend or Other Grown Up
- ☐ TV, Internet, Radio, Books, Magazines, Movies

11. Have you participated in any science competitions (For example: Science Olympiad, science fair, Odyssey of the Mind, Lego Robot Challenge)?

- ○ Yes
- ○ No

---

11 b. If NO above, why do you not participate?

- ○ I plan to do them next year.
- ○ I am interested but my school does not have them
- ○ I heard about them but I am not interested.
- ○ I don't know about them but I am interested.
- ○ I don't know about them and I am not interested.

---

12. Below is a list of types of work that you could do when you are older. As you read about each type of work, you will know if you think that work is interesting. Fill in the circle under the words that describe how interested you are in doing that when you are older. There are no “right” or “wrong” answers. The only correct responses are those that are true for you.

	Not at all Interested	Not so Interested	Interested	Very Interested
Physics: People study motion, gravity and what things are made of. They also study energy, like how a swinging bat can make a baseball switch directions. They study how different liquids, solids, and gases can be turned into heat or electricity.				
Biology: People work with animals and plants and how they live. They also study farm animals and the food that they make, like milk. They can use what they know to invent products for people to use.				
Earth Science: People work with the air, water, rocks and soil. Some tell us if there is pollution and how to make the earth safer and cleaner. Other earth scientists forecast the weather.				

13. Below is a list of types of work that you could do when you are older. As you read about each type of work, you will know if you think that work is interesting. Fill in the circle under the words that describe how interested you are in doing that when you are older. There are no "right" or "wrong" answers. The only correct responses are those that are true for you.

	Not at all Interested	Not so Interested	Interested	Very Interested
Chemistry: People work with chemicals. They invent new chemicals and use them to make new products, like paints, medicine, and plastic.				
Energy/Electricity: People invent, improve and maintain ways to make electricity or heat. They also design the electrical and other power systems in buildings and machines.				
Engineering: People use science, math and computers to build different products (everything from airplanes to toothbrushes). Engineers make new products and keep them working.				

14. **Tell us about yourself.** There are no *right* or *wrong* answers!

	Strongly Disagree	Disagree	In-Between	Agree	Strongly Agree
My family wants me to go to college.					
My family thinks it is important for me to learn science.					
My family knows a lot about science.					
My parents think science is interesting.					
My parents have explained to me that science is useful for my future.					

15. **Tell us about yourself.** Select "yes" or "no" to answer the following statements. If you do not know, select "not sure"

	Yes	No	Not Sure
Did one or more of your parents go to **high school**?			
Did one or more of your parents go to **college**?			
Did one or more of your parents go to **graduate school**?			
Does someone in your family work in a job that uses Science, Technology, Engineering, or Math?			

16. **Tell us about yourself.** Select "yes" or "no" to answer the following statements.

	Yes	No
Do you know anyone who works in a job that uses science?		
Have you been in a science fair or science club?		
Do you know anyone that does science hobbies like watching birds, looking at stars, or building things?		
Have you ever been to a zoo, aquarium, or museum?		
Have you ever talked about science with your family or other adults outside of school?		

17. **Tell us about yourself.** There are no right or wrong answers.

	Strongly Disagree	Disagree	In-Between	Agree	Strongly Agree
My family likes going to zoos, aquariums, or museums.					
I like going to zoos, aquariums, or museums.					
I have learned a lot from going to zoos, aquariums, or museums.					

18. **Tell us what you think.** There are no right or wrong answers.

	Strongly Disagree	Disagree	In-between	Agree	Strongly Agree
People like me have jobs in science.					
I know I can do well in science.					
My friends think I am good in science.					
I think I am good at science.					
I understand most subjects, but science is hard for me.					
I can talk with others about science.					
I am good at using tools in science like thermometers, scales, rulers, or magnifying glasses.					
My teacher sees me as someone who likes science.					
My parents see me as someone who likes science					
I know a lot about science.					
I learn new science topics easily.					
An adult has encouraged me to study science.					

19. **Tell us what you think.** There are no right or wrong answers.

	Not Good	OK	Good
How well do you think you will do this year in **Language Arts**?			
How well do you think you will do this year in **Math**?			
How well do you think you will do this year in **Science**?			

20. **Tell us about yourself.** There are no right or wrong answers. **How many times have you done this in the past year, when NOT in school?**

	Never (0 times)	1 time	2-4 times	5 times or more
Gone to a museum, zoo, aquarium, or planetarium **when not in school**				
Done experiments or used science kits **when not in school**				
Gone on a nature walk **when not in school**				
Read a map to find my way **when not in school**				

21. **Tell us about yourself.** There are no right or wrong answers. **How many times have you done this in the past year, when NOT in school?**

	Never (0 times)	1 time	2-4 times	5 times or more
Collected different stones or shells **when not in school**				
Gone hunting or fishing **when not in school**				
Planted seeds and watched them grow **when not in school**				
Used binoculars or telescope **when not in school**				

22. **Tell us about yourself.** There are no right or wrong answers. **How many times have you done this in the past year, when NOT in school?**

	Never (0 times)	1 time	2-4 times	5 times or more
Used a thermometer to measure temperature **when not in school**				
Used a ruler, measuring tape, or measuring stick **when not in school**				
Built or taken things apart like a radio, watch, or computer **when not in school**				
Talked about science with other people **when not in school**				

23. **Tell us about yourself.** There are no right or wrong answers. **How many times have you done this in the past year, when NOT in school?**

	Never (0 times)	1 time	2-4 times	5 times or more
Watched science TV programs **when not in school**				
Read a book or magazine about science **when not in school**				
Gone online to learn about science on science websites or playing science games **when not in school**				
Done science activities like scouts, 4-H, or science camps **when not in school**				

24. **Tell us what you think.** There are no *right* or *wrong* answers.

	Strongly Disagree	Disagree	In-Between	Agree	Strongly Agree
Scientists do not have a lot of time to spend with their families.					
Scientists like sports as much as other people do.					
Talking to friends about science after school would be boring.					
Scientists like art and music as much as other people.					
Science can help to make the world a better place.					
I would enjoy school more if there were no science lessons.					

25. Some families use different tools at home. **Do you have these items in your home?**

	Yes	No
Map		
Ruler		
Yard/Meter Stick		
Measuring Tape		
Kitchen Scale		
Compass		
GPS		
Measuring Cups		
Weight Scale (Bathroom)		
Timer		
Thermometer		
Health Monitor (blood pressure of health band)		
Chemistry or Science Kit		
Lincoln Logs		
Magnifying Glass		
Legos		
Building Blocks		
Microscope		
Telescope		
Camera		
Calculator		

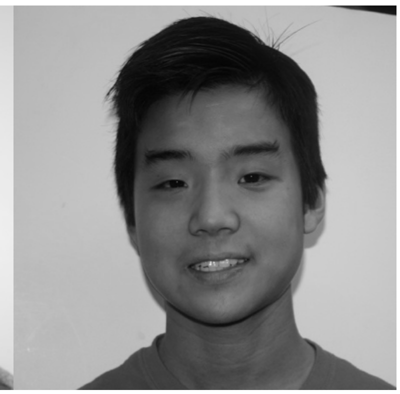
26. Which of these people are a scientist? Circle your answer.

[Image of a young adult, smiling, African American male was inserted here]	[Image of a young adult, smiling, White female was inserted here]
[Image of a young adult, smiling, Asian female was inserted here]	[Image of a young adult, smiling, White male was inserted here]

27. Predict which of the following students will grow up to be a scientist. Circle your answer.

A

B



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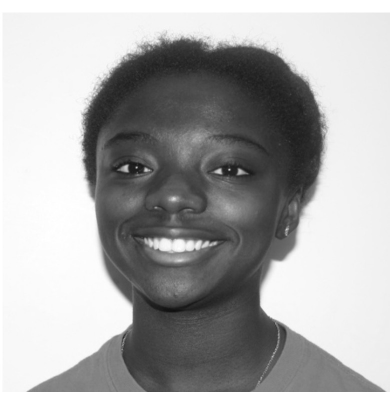

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Appendix B

Adult *NextGen Scientist Survey*

Directions: Please answer each question in this survey. There are no right or wrong answers. We are interested in your ideas.

1. My name is: (First and Last)

2. When you were a child, what did you want to do when you grew up?

3. **Tell us about yourself.** There are no right or wrong answers.
   When you were a child:

	Yes	No	I'm not sure
Did you have access to science tools and toys (science kits, books, tv, etc)			
Did you know anyone who worked in science, technology, engineering, or math fields?			
Did you go to museums?			
If you went to museums, did you feel welcome in those spaces? If you did not go to museums, please skip this question.			

4. Below is a list of types of work related to science. If you could choose any type of work, how interested would you be in the following? Fill in the circle under the words that describe how interested you are in that type of work. There are no “right” or “wrong” answers. The only correct responses are those that are true for you.

	Not at all Interested	Not so Interested	Interested	Very Interested
Physics: People study motion, gravity and what things are made of. They also study energy, like how a swinging bat can make a baseball switch directions. They study how different liquids, solids, and gases can be turned into heat or electricity.				
Biology: People work with animals and plants and how they live. They also study farm animals and the food that they make, like milk. They can use what they know to invent products for people to use.				
Earth Science: People work with the air, water, rocks and soil. Some tell us if there is pollution and how to make the earth safer and cleaner. Other earth scientists forecast the weather.				

5. Below is a list of types of work related to science. If you could choose any type of work, how interested would you be in the following? Fill in the circle under the words that describe how interested you are in that type of work. There are no “right” or “wrong” answers. The only correct responses are those that are true for you.

	Not at all Interested	Not so Interested	Interested	Very Interested
Chemistry: People work with chemicals. They invent new chemicals and use them to make new products, like paints, medicine, and plastic.				
Energy/Electricity: People invent, improve and maintain ways to make electricity or heat. They also design the electrical and other power systems in buildings and machines.				
Engineering: People use science, math and computers to build different products (everything from airplanes to toothbrushes). Engineers make new products and keep them working.				

6. **Tell us about yourself.** Select "yes" or "no" to answer the following statements.

	Yes	No
Do you know anyone, now, who works in a job that uses science?		
When you were in school, were you in a science fair or science club?		
Were you ever in scouts or 4H?		
Do you know anyone, now, that does science hobbies like watching birds, looking at stars, or building things?		
In the last week, did your family talk about science related topics?		

7. **Tell us about yourself and your family.** There are no right or wrong answers.

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
My family likes going to zoos, aquariums, or museums.					
I like going to zoos, aquariums, or museums.					

8. **Tell us about yourself.** There are no right or wrong answers.
How many times have you done this in the past year?

	Never (0 times)	1 time	2-4 times	5 times or more
Gone to a museum, zoo, aquarium, or planetarium				
Gone on a nature walk				
Read a map to find my way				

9. **Tell us about yourself.** There are no right or wrong answers.
How many times have you done this in the past year?

	Never (0 times)	1 time	2-4 times	5 times or more
Gone hunting or fishing				
Planted a garden				
Used binoculars or telescope				

10. **Tell us about yourself.** There are no right or wrong answers.
How many times have you done this in the past year?

	Never (0 times)	1 time	2-4 times	5 times or more
Used a thermometer to measure temperature				
Used a ruler, measuring tape, or measuring stick				
Built or taken things apart like a radio, watch, or computer				
Talked about science related topics with other people				

11. **Tell us about yourself.** There are no right or wrong answers. **How many times have you done this in the past year?**

	Never (0 times)	1 time	2-4 times	5 times or more
Watched science TV programs				
Read a book or magazine about science				
Gone online to learn about science on science websites or videos				

12. Tell us about yourself. There are no right or wrong answers.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
People like me have jobs in science					
I am interested in science					
I think I am good at science					
I can talk with others about science					
I am good at using science tools like thermometers, scales, rulers, or magnifying glasses					
I know a lot about science					
I learn new science topics easily					

13. **Tell us about yourself**. There are no right or wrong answers.

	Yes	No	I'm not sure
Do you see yourself as a science person?			
Do you think your friends see you as a science person?			
Do you think your family sees you as a science person?			

14. **Tell us about your child**. There are no right or wrong answers.

	Yes	No	I'm not sure
Do you think your child sees him/herself as a science person?			
Do you think your child's friends see him/her as a science person?			
Do you see your child as a science person?			

15. **Tell us about your child.** There are no right or wrong answers.

	Not Well	Ok	Very Well
How well does your child do in math class?			
How well does your child do in science class?			

16. **Tell us what you think.** There are no right or wrong answers.

	Yes	No	I'm not sure
Would your child consider a career in science?			
Would your child consider a career in technology?			
Would your child consider a career in engineering?			
Would you recommend a career for your child that involves science?			
Would you recommend a career for your child that involves technology?			
Would you recommend a career for your child that involves engineering?			
Do you think there is a certain "type" of person who becomes a scientist or engineer?			
Does your child fit that "type" of person?			
Do you think being a boy or a girl makes a difference in a child's interest in science, technology, or engineering?			
Do you think a child's home background makes a difference in whether a person would want to study science, technology or engineering?			

17. Tell us what you think. There are no right or wrong answers.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Scientists do not have a lot of time to spend with their families					
Scientists like sports as much as other people do					
Scientists like art and music as much as other people					
Science can help to make the world a better place					

18. Some families use different tools at home.
Do you have these items in your home?

	Yes	No
Ruler		
Weight Scale		
Magnifying Glass		
Compass		
Thermometer		
Telescope		
Calculator		
Map		
Yard/Meter Stick		
Kitchen Scale		
GPS		
Measuring Cups		
Timer		
Health Monitor (Blood Pressure or Health Band)		
Chemistry or Science Kit		
Lincoln Logs		
Legos		
Building Blocks		
Microscope		
Camera		

What is your zip code?

Which of these best describes the area you live?

- Urban
- Rural
- Suburban

I am:

- African American/African
- Caucasian/European
- Hispanic/Latino
- American Indian/Native Alaskan
- Native Hawaiian/Other Pacific Islander
- Middle Eastern
- South Asian/Indian
- East Asian
- Other ____

I am:

- Male
- Female

What is your highest level of education?

- Some high school
- Graduated high school
- Some college
- Two year college
- Four year college
- Some graduate school
- Completed a graduate degree

What is your occupation?

Do you use science in your work?

- Yes How:____
- No

Tell us about yourself. Select "yes" or "no" to answer the following statements. If you do not know, select "not sure".

	Yes	No	Not sure
Did one or more of your parents go to high school?			
Did one or more of your parents go to college?			
Did one or more of your parents go to graduate school?			
Does someone in your family work in a job that uses Science, Technology, Engineering, or Math?			

Which of these people are a scientist? Circle your answer.

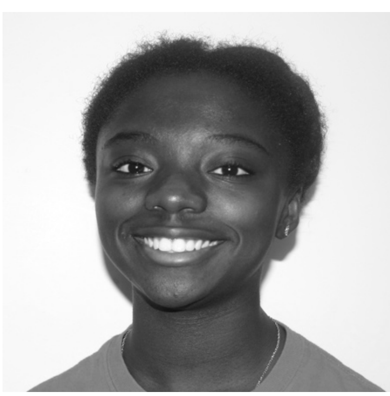
[Image of a young adult, smiling, African American male was inserted here]	[Image of a young adult, smiling, White female was inserted here]
[Image of a young adult, smiling, Asian female was inserted here]	[Image of a young adult, smiling, White male was inserted here]

Predict which of the following students will grow up to be a scientist. Circle your answer.

A

B

C



D

E

F

Supplemental End of Year Questions

How has this program impacted your family?

Has the program influenced you (as a parent) in any way? If so, please give some examples.

Has the program influenced the other children who came with you in addition to your child enrolled in the program? If so, please give some examples.

Appendix C

Adult Interviews

Initial Interview

Initial FAME Parent Interview Protocol

Location:_______________________________ Date:_______________

Name of Parent :_________________________________

Hi, my name is ____ and I am a _____ student at NC State and I will be talking with you today. We are so glad you have decided to be a part of our Circle of Friends. When you applied to be part of the Circle of Friends, you signed a consent form agreeing to participate in two interviews and a couple surveys. Today we will be doing our first interview. In the consent form, we promised we will keep your information confidential and will never share anything with your name on it. We will be using pseudonyms (a fake name) for each participant. Would you like to select your pseudonym?

Pseudonym (Ask for spelling if needed): ____

As we go through the questions, I will be writing down what you are saying, word for word. So, I may need to ask you to stop or slow down so I can make sure I get everything you say. If at any time, you feel the need, we can stop the interview. However, you do have to complete both interviews and the surveys to receive the gift cards.

The purpose of this study is to learn how a family STEM program influences youth interest in science. It is perfectly ok if you or your child do not like science. We are interested in what you and your child do like and what kinds of experiences shape those feelings.

We also know museums can be unusual places. Not everyone feels comfortable. So, we are also interested in how you feel about being at this museum but also museums in general. We are interested in how people's experiences with science and engineering influences the things they do with their families.

We are interested in your thoughts about your experience with this program. We want to know how you and your child feel about this program- both your likes and dislikes. The goal of this study is to build a better program that families enjoy.

- Do you have any questions before you begin? (please write the questions)

About the Program:

1. Tell me a little bit about why you and your child chose to participate in this program.
2. What are your expectations for the program?
3. Now that you have heard a little about the activities we have planned for you and your family this year, what sounds the most interesting?

a. What sounds the least interesting?

Background information:

4. Can you tell me about who makes up your family?
5. Are you from the [local] area?
6. Do you mind if I ask what you do for work?
7. Tell me a little about your educational background.
8. When you were a child, what did you want to do when you grew up?
    a. Did you ever work in a job related to that career?
    b. Were you supported in this goal?
    c. Did you know anyone who had this job as a young person?
    d. If yes, who? (friend, family, etc)
9. Growing up, do you remember having science related toys, activities, or books in your home?
10. Were you confident in your skills in science or math as a child?
11. Growing up, did you know anyone who worked in science, technology, engineering or math related fields?
12. Did you go to museums as a child with your family?
    a. If yes, did you feel welcome in those spaces?
13. What is a typical Saturday like for your family?
14. If you had a free day with your family, how would you like to spend it?
15. In your free time, does your family do science oriented activities? Why or why not?
16. Do you take your family visit museums? Why or why not?
17. Tell us about your child.
18. What does your child do in his/her free time?
19. Does your child talk to you about school?
    a. If yes: How often? When your child talks about school, what do you talk about?
20. Does your child enjoy school?
21. What is your child’s favorite/least favorite subject?
22. In what areas does your child excel?
23. How much education would you like your child to have?
24. What careers do you think are important for your child to consider?
    a. Do you talk with your child about these careers?
    b. What will your child need to do to prepare this career?
    c. What barriers do you see for your child to pursue this career?
    d. What support do you need as a parent to help your child succeed in this area?
25. Do you think of science and engineering as the same or different? (what do the terms mean to you?)
26. Do you find science or engineering interesting? Why or why not?
27. Would you describe yourself as a science person?
28. Does your child like science, technology, engineering or math? Do you have ideas about why/why not?
29. How does your child do in their math and science classes at school?
30. Would your child think about a career that uses science, technology, engineering or math? What do you think about this?

31. Do you think that there is a certain "Type" of person who becomes a scientist or engineer? Does your child fit this type? Why or why not?
32. Do you think being a boy or a girl makes a difference in a child's interest in science, technology, engineering or math?
33. This next question is from a study of student interest in science conducted in England. We are interested in what US parents think. Do you think a child's home background makes a difference in whether a child would want to study science, technology, engineering or math? Why?

People as scientists

34. On your survey, you chose this person/these people as a scientist, can you tell me why?
35. On your survey, you chose this child/these children as potential scientists, can you tell me why?

Parent Midyear Interview

MidYear FAME Parent Interview Protocol

1. What have you liked best so far about the program?
2. What have you liked least so far about the program?
3. So far in the program, you have completed the following activities: [fill in for each museum]. We know not every activity is as interesting as the others so you do not have to rate them all positively. First I'd like to know about your views and then I'll ask about your child's.
    a. Which program was most interesting?
    b. Which was least interesting?
    c. Why?
    d. Is there anything you've done that you'd like your family to continue doing outside the program?
4. As every kid is unique, what activities do you think your child liked the most? Which activities do you think your child like the least?
5. So far you have received the following take home activities: [fill in for each museum]. We recognize they might not all be as interesting to you and your family so you do not have to rate them all positively.
    a. Have you been using them?
    b. How?
    c. Which were the most interesting?
    d. Which were the least interesting?
6. Taking on an extra activity on weekends come with benefits and challenges.
    a. Has your family experienced any benefits from participating in this program?
    b. Has your family experienced any challenges so far?
7. This program is different from most in that we are asking families to engage in the program together.
    a. What have been the benefits to this type of program compared to a drop off program?

    b. What have been the challenges to this type of program compared to a drop off program?
    c. Did you bring any children in addition to your child enrolled in the program?
    d. Have those children benefitted from the program? In what ways?
8. Programs like this can be run in a variety of settings- the YMCA, Boys and Girls Clubs, Schools, Community Centers, Museums.
    a. Can you think of any advantages or disadvantages to having this program at the museum (and prairie ridge) versus other locations.
9. Over the last few months, can you think of instances when you have talked about science with your child, either related to this program or not?
    a. Did anything in this program trigger those conversations?
    b. Is that typical of the conversations you had before the program or have they changed with the program? (if yes, probe)
10. Has your family used any technology related to science since the program started?
11. Have you used social media to engage your child with science during the program?
    a. Have you checked out our @STEMFamilies twitter page?
12. If you had could have input for future planning, what suggestions would you make?

End of Year Interview

Final FAME Parent Interview Protocol

Name of Parent:
Name of child:

Hi, my name is _______ and I am a _____ student at NC State and I will be talking with you today.
We are so glad you have decided to be a part of our Circle of Friends. When you applied to be part of the Circle of Friends, you signed a consent form agreeing to participate in two interviews and a couple surveys. Today we will be doing our first interview. In the consent form, we promised we will keep your information confidential and will never share anything with your name on it.

As we go through the questions, I will be writing down what you are saying, word for word. So, I may need to ask you to stop or slow down so I can make sure I get everything you say. If at any time, you feel the need, we can stop the interview. However, you do have to complete both interviews and the surveys to receive the gift cards.

Do you have any questions before we begin? (write down any questions)

Background:
1. Has anything changed at work or family life since we last talked to you? (new job, moved, etc)
2. Can you tell me about your experiences with science *in school* as a child? (Probe, did you like science in school?)

3. Can you tell me about your experiences with science *outside of school* as a child? (Probe, did you have any science hobbies)?
4. Did you like science as a child?
5. Did you see yourself as a science person growing up? Why or why not?
6. Were you confident in your science skills as a child? Why or why not?
7. Did you have a favorite science teacher?
    a. If yes, what can you remember about them?
8. Did you know anyone, as a child, who worked in STEM? (if yes, who? Did you know they had a STEM career as a child?)

About the program

9. Tell me a little bit about why you and your child chose to participate in this program?
    a. Did this program help you accomplish those goals?
    b. If you had not been told you would receive an iPad and Summer Camp, do you think you would have attended as often as you did?
10. What was your favorite part of participating in this program?
11. What was your least favorite part of participating in this program?
12. What would you have liked to see more of during the program?
13. Was there anything you would have liked to have learned about? (topic, career, etc)
14. Would you have liked to be more involved or engaged during the program? Why/Why not?
    a. If yes, how would you have liked to be more involved?
15. Did you learn more about careers in STEM that your child might be interested in? (If they need help remembering what they were: [fill in for each museum]. (Probe: which ones? Why?)
16. Your family received the following take homes: [fill in for each museum]. Did you use the take home activities after the programs?
    a. Which were the most interesting?
    b. Which were the least interesting?
17. Would you recommend this program to other parents? why/why no?
18. How would you describe the goals of this program to another parent?
19. You and your child have invested a lot of time in the program, could you tell us about the experience and what the program has meant for you as a family?
    a. Has this program influenced you in any way?
    b. Has the program influenced any other children who attended with you? (who else did they bring?)

About the family:

20. Now that you've been in the program, do you spend more time talking with your child about science, technology, engineering or math? Why or why not?
    a. Does your family talk more about STEM?
21. Has the program changed how you feel about museums or science centers? Why or why not?
22. Have you visited other museums outside of this program this year?
23. Is your family more likely to visit a museum or science center now that you participated in the program?

24. In your free time, does your family do science oriented activities? Why or why not?
25. Do you have any family members that work in STEM careers?
26. Are you interested in science or engineering? Why or why not?
27. Would you describe yourself as a science person now?
28. Was there anything in the program that exposed you to new science interests, careers, or hobbies?
29. There are lots of factors that influence a person's decision to major in science or engineering. When you reflect on your own life, were there any resources, experiences, or access to mentors that encouraged you to choose a career in STEM?

About the Child:

30. Has your child talked about the program at home?
31. Did your child enjoy the take home activities? Which ones in particular did they like?
32. What careers do you think are important for your child to consider?
    a. Has this changed since the program began?
    b. Have you encouraged your child to consider those jobs? (Do you talk with your child about these careers?
    c. What will your child need to do to pursue this career?
    d. What barriers or challenges do you see for your child to pursue this career?
    e. What support do you need or would like as a parent to help your child succeed in this area?
34. You initially said your child was a science person. Do you still feel that way? Why/not?
35. You initially said your child was good at science. Do you still feel that way? Why/not?
36. (For families that had discrepancies) Your child said that they felt they were/weren't a science person and you disagreed. Why do you think that may be?
37. Does your child talk to you about school?
    a. If yes: How often? When your child talks about school, what do you talk about?
    b. Do they ever talk to you about the science they do in school? Can you give an example?

About Science and Engineering- these questions will help us better understand your views of science and engineering after participating in the program

39. Does your child like science, technology, engineering or math? Why or why not?
40. How does your child do in their math and science classes at school? Has this changed since entering the program?
41. Does your child want a career that involves science, technology, engineering, or math? What do you think about this?
42. Would you recommend a career for your child that involves science, technology, engineering, or math? Why or why not?
43. Are there any resources, experiences, or mentors your child will need to be able to pursue a career in STEM?
44. Do you think that there is a certain "type" of person who becomes a scientist or engineer? Does your child fit this type? Why or why not?
45. Do you think being a boy or a girl makes a difference in a child's interest in science, technology, engineering or math? Why or why not?
46. This next question is from a study of student interest in science conducted in England. We are interested in what US parents think. Do you think a child's home background

makes a difference in whether a child would want to study science, technology, engineering or math? Why or why not?

47. We know from research that African American and Hispanic students do not tend to choose science related majors or careers. In your experience, have you found this to be true? Why or why not?
    a. No, I guess I've seen my classmates, my family members... I've been introduced to different
48. What do you think that schools, policy makers, families and communities could do to increase the number of women and underrepresented people to choose science related majors or careers?
49. Research shows that African American and Hispanic families often feel uncomfortable or unwelcome in museums. Did you feel welcome at the museum?
    a. (If yes), Were there ever times that made you feel less comfortable at the museum?
    b. Do you think that's true for other African American and Hispanic families?
50. Is there anything else you think we should know that we haven't talked about yet?

We would like to follow up with your family once or twice next year at times that would be convenient for you. Would that be ok?

What would be the best way for us to contact you? Phone or email?

What is their phone or email? _____________

Appendix D: Codebook

Codes	Definitions	Examples
Science Capital and habitus	Science capital refers to the resources (economic, cultural and social) one has related to science (Archer, Dawson, DeWitt, Seakins, & Wong, 2015). Family science habitus is described by Archer and her colleagues (2012) as the way a family's economic, social, and cultural capital influences their collective relationship with science and how they identify, value, discuss, and "do" science.	science toys, knowing someone who has a stem career or hobby, knowledge about science and science activities, science experiences, science knowledge. Doing activities related to science, attitudes towards science, "I am interested in science"
Social Capital	The system of relationships and resources an individual develops through interactions with other people and communities builds social capital (Bourdieu, 1986; Yosso, 2005). These resources and relationships are important for helping an individual comprehend and negotiate social fields of practice (Yosso, 2005).	meeting families who also like science, meeting other kids who like science
Familial Capital	Familial capital is considered an expansion of social capital and is often interchanged with family capital or family social capital (Williams & Dawson, 2011). Familial capital includes the forms of cultural knowledge within a family such as a shared history or memories and includes a broad concept of family which includes extended family and non-relatives (Yosso, 2005).	Spending time with family, learning what your children know about science
Aspirational Capital	Aspirational capital allows an individual to have goals and ambitions for the future despite any barriers they may perceive or experience (Yosso, 2005). This form of capital enables individuals to have goals for themselves, or others, that may appear to lay beyond their current situation and means.	Having stem career goals for self or child, not knowing about these things, that's more like navigational, or learning about them, that's more science capital
Navigational Capital	Navigational capital is what allows individuals to negotiate social institutions (Yosso, 2005) including educational spaces. Yosso further explains that students' navigational capital empowers them to maneuver within unsupportive or hostile environments	Knowing how to get scholarships or find STEM activities for your child

Linguistic Capital	Linguistic capital is a result of learning to communicate in more than one language or style and brings a set of intellectual and social skills such as being able to communicate through storytelling, art, or music (Yosso, 2005). Language plays an important role in allowing individuals access to institutionalized capital in areas such as science (Claussen & Osborne, 2013). Linguistic capital is representative of the languages and communication skills that youth from nondominant backgrounds often bring with them (Yosso, 2005).	Using science vocabulary, talking about science as a family